A GIS-based Spatial Equity Assessment Framework: Measuring Potential Accessibility and Assessing Spatial Equity of Healthcare Services Integrating Size and Quality for Social Groups at the Household Level on the City Scale

-- A Case Study of GP Practices in the UK

A THESIS SUBMITTED FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

CHENGCHENG WU

SCHOOL OF ARCHITECTURE, PLANNING AND LANDSCAPE,
NEWCASTLE UNIVERSITY

APRIL 2018

Abstract

This research intends to develop a more comprehensive and accurate GIS-based Spatial Equity Assessment Framework. The purpose is to provide guidance for measuring potential accessibility integrating size and assessing spatial equity integrating quality for social groups at the household level on the city scale.

The research reviews the existing studies in planning and health-related fields on disaggregation techniques, potential accessibility and potential access measurement and spatial equity assessment. As the most accurate place access measurement method, the Population Weighted Centroid (PWC) technique suffers from aggregation errors, a cadastral and address-based population weighting technique, the Household Space Weighting (HSW) technique is developed to measure population access. The HSW technique is formally tested in a case study of General Practitioner (GP) surgeries in Newcastle upon Tyne, UK. The findings suggest that the PWC technique produces inaccurate population estimations for 267 out of 910 output areas in the city. When applying the two techniques to measure potential accessibility for social groups, taking into account the overlay of service areas on the city scale, the measurement error for the PWC technique is 9-11%, depending on the social group considered. The relative difference in the percentage of social groups with potential access applying the two techniques is 18-22%. This suggests that if service planners or policy makers want to measure potential access to services for social groups in their cities, it would be useful to apply a more accurate population weighting technique, or to at least be aware of the implications of applying the PWC technique.

The research also demonstrates the necessity of incorporating *demand* apart from *equality* and *need* and integrating quality in addition to size into spatial equity assessment framework. Thus, the GIS-based Spatial Equity Assessment Framework that is developed in this research is more comprehensive and accurate than the existing studies. The research summarizes how to apply the assessment framework to provide policy recommendations for cities on the city scale. The assessment framework has potential to extend from measuring potential access and assessing spatial equity of healthcare services to other services and from measuring potential access to realized access.

Acknowledgements

First of all, I would like to thank my first supervisor, Dr. Neil Powe, for his patient advice and encouragement during the whole process of my PhD particularly in tough times. I would also like to thank my second supervisor, Dr. Alison Copeland, for her kind suggestions especially on data and research methods when I was struggling to figure them out. I have been very lucky to have both of you. Besides, I would like to extend my gratitude to other members of staff in the School of Architecture, Planning and Landscape for their continued support and guidance on administrative procedures. This research would have been much more difficult without their great help. Finally, I would like to thank my parents and all my friends who have shared ups and downs during the process and helped me become a mentally strong person when approaching the end of the journey.

Table of Contents

List of Maps

List of Figures

List of Tables

List of Abbreviations

CQC Care Quality Committee

FTE Full Time Equivalent

GP General Practitioner

HSW Household Space Weighting

IMD Index of Multiple Deprivation

ITN Integrated Transport Network

NICE National Institute for Health and Care Excellence

OA Output Area

ONS Office for National Statistics

OS Ordnance Survey

SA Service Area

PWC Population Weighted Centroid

SIMD Scottish Index of Multiple Deprivation

Definitions

Equity: is "an issue of distributive justice" concerning "what is fair" (Lucy, 1981: 448); in terms of the distribution of services, *equity* is concerning "'Who gets what?' or, normatively, 'Who ought to get what?'", which involves "a multitude of value judgments about *who* should benefit" (the extent to which the disadvantaged/advantaged social groups should be spatially defined) (Wicks and Crompton, 1987:189); *equity* is also concerning 'how the distribution can be measured?', which involves the methodology for distributing services in an equitable way (Talen, 1998).

In order to incorporate *equity* into planning process, Lucy (1981) relates the following five alternative concepts, *equality*, *need*, *demand*, *preferences* and *willingness to pay*. Talen (1998) identifies four conceptions of *equity* that are relevant to planning for services: *equality*, *need*, *demand* and *equity defined by market criteria*.

Equality: describes that everyone should receive the same benefits from services, "regardless of socioeconomic status, willingness or ability to pay, or other criteria; residents receive either equal input or equal benefits, regardless of need" (Talen, 1998:24). However, the physical limitation (i.e. the impossibility to locate services equidistant to potential users) requires the adoption of threshold standards (e.g. using distance and/or density as the basis for location and size recommendations) to assess *equality* in the realm of services (Lucy, 1981).

Need: refers to the principle that each spatially defined disadvantaged social group should receive disproportionately more benefits from local services (Talen, 1998). This is consistent with the idea that "unequals should be treated unequally", meaning "those needing more service should receive more, rather than less"; unequal treatment here requires "some defensible basis for the inequality", which requires the basis for identifying needs for social groups in accordance with their socio-economic status and demographic characteristics (e.g. households classified by deprivation) (Lucy, 1981:448-449).

Demand: refers to the principle that an equitable distribution of services in accordance with demands, where "active participation in distributive decisions is 'rewarded' by increased user benefit" (Talen, 1998:24). This is manifested through the use of services taking into consideration heavy and light users of those services, which requires the identification of social groups with higher and lower rates of usage, for instance social groups with higher and lower GP consultation rates classified by age group in the context of healthcare services (Lucy 1981; Rogers et al., 1999).

Equity defined by market criteria: describes that an equitable distribution of services should be made in accordance with market criteria. This makes the cost of services a key factor to determine the distribution of services, particularly when it comes to willingness to pay that reflects the extent to which people use specific services thus pay for them (Talen, 1998).

Spatial equity: refers to "the degree to which services or amenities are distributed in an equal way over different areas as well as economic, ethnic and political groups, with appropriate consideration given to the needs of special groups" (Omer, 2006:254-255). As *spatial equity* focuses on the socio-spatial dimension of *equity*, this research assesses spatial equity based on *need* and *demand* as well as *equality* in the form of *need-based equal access* and *demand-based equal access* within a certain distance threshold.

Access: is a multi-dimension concept in health-related research field, which is "viewed as a general concept that summarizes a set of more specific dimensions describing the fit between the patient and the health care system", including *availability*, *accessibility*, *accommodation*, *affordability* and *acceptability* (Penchansky and Thomas, 1981:127).

Potential access: refers to the "availability of that service moderated by space, or the distance variable" (Khan, 1992:275). In this conceptualization, *access* is "the outcome of a process, determined by an interplay between the characteristics of the health care service system (e.g. the size and distribution of health care facilities) and the characteristics of the population-at-risk in a specified area (e.g. age, health status, insurance coverage and income levels), and moderated by health care related public policy/planning efforts" (Khan, 1992:275).

Realized access (or ***Utilization***): is the actual use of services or actual entry into the healthcare system, the realization of which depends on the interplay between barriers and facilitators, which reflects both potential users and the healthcare system (Anderson, 1995; Khan, 1992).

Spatial access (or ***Geographical access***): is associated with spatial aspects such as distance of potential users to healthcare services; ***Aspatial access*** (or ***Social access***) is associated with characteristics of population and healthcare services (Joseph and Bantock, 1982; Khan, 1992).

Place access: is related to an approach measuring access using geographic centroids or population-weighted centroids to represent geographical or administrative units; ***Population access***: is associated with an approach measuring access for populations (e.g. residents) and/or its subgroups (e.g. social groups) rather than geographical or administrative units (Talen, 2003).

Pedestrian-oriented access*:* is related to an approach measuring access for locally oriented populations (such as the elderly, the disabled and the poor) who rely on modes of transport other than the automobile; ***Automobile-oriented access***: is associated with an approach measuring access for populations with private cars or public transport as modes of transport (Talen, 2003).

Accessibility: refers to "people's ability to use services and opportunities" (Litman, 2015:5). It "describes geographical barriers including distance, transportation, travel time, and cost", which emphasizes the geographical location of services in relation to population in need" (Cromley and McLafferty, 2012:304).

Potential accessibility: refers to geographical or spatial relationship between healthcare services and residents in their surrounding areas (Love and Lindquist, 1995). It is related to the opportunity for residents to use healthcare services, which allows researchers to assess the nature and pattern of geographical or spatial access to healthcare services between potential users and healthcare services available over space (Martin *et al*., 2002; Higgs, 2004).

Realized accessibility: is related to the actual use of healthcare services (Martin *et al*., 2002). The examination of actual utilization patterns takes into consideration the factors such as physical distance, socio-economic factor (e.g. employment, income, education, housing, etc.) and demographic factor (e.g. age groups) (Love and Lindquist, 1995).

Resident: refers to a usual resident of the UK as at census day 27 March 2011, meaning "anyone who, on census day, was in the UK and had stayed or intended to stay in the UK for a period of 12 months or more, or had a permanent UK address and was outside the UK and intended to be outside the UK for less than 12 months" (Office for National Statistics, 2011).

Deprivation: refers to a set of characteristics of households containing four dimensions (Employment, Education, Health and Disability, and Housing) used to classify that a household is deprived if it meets the conditions identified in one of the four dimensions (Office for National Statistics, 2011).

Heavy/Light User Group: The *Heavy User Group* is the most frequent user group of healthcare services, here referring to residents classified by age who have the highest GP consultation rates (i.e. young children aged 0-4 and the elderly aged 75 and over); while the *Light User Group* is the least frequent user group of healthcare services, here referring to residents classified by age who have the lowest GP consultation rates (i.e. the rest aged 5-74) (Rogers *et al*., 1999).

Population Weighted Centroid: represents "the spatial distribution of the population in each instance of its geographies, as recorded in the 2011 Census, as a single summary reference point on the ground" (i.e. OA, LSOA and MSOA); "each population weighted centroid was calculated using a median centroid algorithm, the result of which is less influenced by outliers than the result of an algorithm to calculate the mean centroid"[1] (ONS Website, 2016).

Population Weighted Centroid (PWC) Technique: is a population weighted technique to making population estimation inside Service Areas and measuring place access to services using population weighted centroids to represent census units when applying the *Have Their Centre In* criterion, i.e. census units with population weighted centroids located inside Service Areas are counted as with access, otherwise without access.

Household Space Weighting (HSW) Technique: is a cadastral and address-based population weighting technique and a population access measurement method to making population estimation inside Service Areas and measuring population access to services by spatially disaggregating the lowest-level census data available to the household level using ancillary data reflecting the number of Houses in Multiple Occupancy of residential buildings by dwelling type in use (i.e. Household Spaces) to represent the number of households. It calculates the proportion of Household Spaces within census units located inside Service Areas, and signs weights to census units with access accordingly. Census units with all Household Spaces located inside Service Areas are counted as with full access, census units with parts of Household Spaces located inside Service Areas are counted as with partial access, and census units with no Household Space located outside Service Areas are counted as with no access.

[1] "The median algorithm used was the Median Center (sic) function in ArcGIS 10.0, running against the coordinates and the populations of each household in each OA, LSOA and MSOA"; "where the calculated centroid fell outside the boundary of the area being calculated, or within two metres of the area boundary, it was moved to the nearest location at least two metres inside the area boundary" (ONS Website). Available from: http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html

Chapter One: Introduction

1.1 Background to the Research

The just distribution of services is a significant and challenging goal for planners and policy makers because the realization of which can maximize equitable access to services (Talen, 1998). Lucy (1981) relates *equity* to five concepts that are relevant to distributive principles for services planning and integrates them into more planning processes to help facilitate the application of *equity* concepts in policy and decision making.

Spatial equity refers to "the degree to which services or amenities are distributed in an equal way over different areas as well as economic, ethnic and political groups, with appropriate consideration given to the needs of special groups" (Omer, 2006:254-255). It focuses on determining what factors account for or are associated with spatial variations in service distribution (Talen, 2001). *Access* can be used as a tool to investigate whether equitable distribution of services has been achieved or not (ibid.). Thus, potential inequitable access to services caused by the continuous distribution (sometimes uneven though) of populations throughout a city and the distribution of services located at discrete point locations (Hewko et al. 2002; Knox, 1978) can be analyzed and measured by applying these two concepts. In assessing access to services, geographical analysis of spatial equity requires measurement, where the conclusions of spatial equity assessment will be sensitive to how this measurement is conceptualized and calculated (Talen, 2003; Talen and Anselin, 1998).

Among other services, the equitable access to healthcare services is one of the key priories of the UK Governments' policy agenda to achieve social inclusion and social justice (Department of Health, 2002; 2003). Concerning healthcare services, GP practices are of considerable importance within advanced healthcare delivery systems as it not only provides basic health care but also acts as a gatekeeper to higher levels of health care (e.g. secondary and tertiary healthcare services) (Joseph and Bantock, 1982). The GP practice has been included as one of the key local services in the *English Index of Multiple Deprivation (IMD) 2015* (DCLG, 2015) and *the Scottish Index of Multiple Deprivation (SIMD) 2012* (The Scottish Government, 2012), the potential accessibility of which is measured and used as one of the indictors to assess deprivation. Besides, a variety of methods and techniques have been proposed and applied in the existing research to better measure potential accessibility and potential access to healthcare services using GP practices as a case study.

However, reviewing the literature reveals that there is a lack of comprehensive and accurate GIS-based spatial equity assessment framework. A framework can be used to guide the assessment of spatial equity integrating the quality of services by measuring potential accessibility integrating size (i.e. potential access) for social groups at the household level on the city scale. Despite frequent references to 'equitable access to health care' either in research or policy, little agreement has been reached in the health-related literature on its specific meaning; the absence of a commonly accepted interpretation of equitable access to healthcare services has caused problems such as inconsistency in healthcare policies (Oliver and Mossialos, 2004). Although there has been a longstanding goal to investigate the opportunities available to populations in healthcare services and medical geography research (Delamater, 2013), due to resource constraints, it is necessary to set priorities in healthcare provision so as to help make sure that more healthcare services can be provided to residents with greater healthcare needs and demands.

In fact, access to healthcare services from spatial perspective contains both *availability* and *accessibility* (Khan, 1992). This requires the integration of the size of healthcare services (representing availability) into accessibility measurement. The method that is applied in planning literature to identify the size of services located inside Service Areas for each demand point (called the 'Coverage' method) involves the measurement of the size of services (e.g. Comber *et al.*, 2008; Nicholls, 2001; Omer, 2006; Smoyer-Tomic *et al*., 2004). However, even though the method itself is related to spatial equity assessment, the size that is measured in that context is more related to physical size of services (such as the area of public parks) rather than the *availability* of the services. The methods using travel time/distance floating catchment areas instead of fixed geographic or administrative boundaries in health-related literature (i.e. the 2-Step Floating Catchment Area (2SFCA) method and its enhanced versions, e.g. Luo and Wang, 2003; Luo, 2004; Wang and Luo, 2005) are integrated availability and accessibility approaches to measuring potential access. But they are designed to identify physician shortage areas, a relative measurement calculating the physician-to-population ratio rather than assessing spatial equity.

Besides, both the 'Coverage' and 2SFCA method and its enhanced versions do not integrate the quality of healthcare services, which is not comprehensive particularly when it comes to the measurement of potential access and the assessment of spatial equity for

social groups. Furthermore, both methods cause aggregation errors, as they apply the *Have Their Centre In* criterion (Nicholls, 2001) while measuring potential access, meaning that they only estimate either total population inside Service Areas (or full access) or no population inside Service Areas (or no access).

In overcoming the aggregation error issue, there are spatial disaggregation techniques (e.g. dasymetric mapping techniques) which intend to identify the location of population by locating residential buildings in the absence of house-level census data. The most updated technique is a population weighting technique, the Cadastral-based Expert Dasymetric System (CEDS) proposed by Maantay *et al*. (2007). The CEDS technique uses cadastral data as its ancillary data, which specifically uses the Residential Area and the number of Residential Units as proxies for population distribution, with the assumption that areas with more potential living accommodations have higher populations. The difference between the CEDS technique and the other forms of dasymetric mapping techniques is that it does not use areal weighting or the binary method; it uses detailed cadastral data as its ancillary data to make population estimation rather than using remotely sensed land cover/land use data to estimate population density classes. Maantay et al.'s research compares the application of the CEDS and the Filtered Areal Weighting techniques to estimate population, the result of which shows that the CEDS technique is more accurate than the Filtered Areal Weighting technique in population estimation. However, Maantay et al.'s (2007) research uses geographic centroids to represent the lowest census units (the Tax Lot) that it disaggregates into as it did not manage to disaggregate census data to house level. Thus, the CEDS technique is a place access rather than a population access measurement method when it is applied to measure potential access.

Concerning the problem related to the use of geographic centroids, there is a more advanced technique using population weighted centroids instead of geographic centroids, which takes into consideration the location of households within census units. The use of population weighted centroids replacing geographic centroids when applying the *Have Their Centre In* criterion (called the Population Weighted Centroid (PWC) technique) in population estimation inside Service Areas is more accurate as the location of households within census units is taken into account. However, the population weighted centroid is a single summary reference point of census unit (ONS Website, 2016). Thus, the PWC technique is still a place access rather than a population access measurement method

when it is applied to measure potential access, although it provides more accurate representation of census units than the geographic centroid as used in the CEDS technique.

The use of the *Have Their Centre In* criterion in applying the PWC technique assigns the weight of '1' to the census units with their population weighted centroids located inside Service Areas and the weight of '0' to the census units with their population weighted centroids located outside Service Areas, and then calculates and sums up associated populations. The use of the population weighted centroids and the weight of either '1' or '0' assigned to census units here is a source of aggregation errors. Because it is not likely that population within census units locate either inside or outside Service Areas. Rather, they locate fully or partially inside Service Areas or outside Service Areas due to the uneven distribution of the population and the heterogeneity of physical environment within each census unit (Crawford, 2006; Hewko *et al*., 2002; Knox, 1979; Pham *et al*., 2012). Thus, it requires the identification of an accurate spatial disaggregation technique that can be used to spatially disaggregate the lowest level census unit data available (e.g. Output Area in the UK) to the household level to increase the accuracy by taking account of the population within census units that locate partially inside Service Areas.

Based on the above analysis of research gaps, it is necessary to develop a more comprehensive and accurate spatial equity assessment framework. A framework of an integrated availability and accessibility approach, which integrates size into potential accessibility measurement and quality into spatial equity assessment for social groups at the household level on the city scale. To achieve this, it is necessary to do the following: i) developing a more comprehensive conceptual framework for spatial equity assessment based on existing studies; ii) proposing a more accurate disaggregation technique; iii) calculating the size weighting that reflects *availability*; iv) applying the more accurate disaggregation technique to measure potential accessibility integrating size (i.e. potential access) for social groups at the household level on the city scale; and v) assessing spatial equity of healthcare services integrating quality on the city scale.

Concerning the conceptual framework, apart from the *equality* and *need* conceptions, the *demand* conception can also be incorporated to assess spatial equity based on Lucy (1981) and Talen's (1998) conceptualization and conceptions of equity and Omer's (2006) definition of spatial equity. To further reduce the aggregation error caused by using population weighted centroids to represent census units in potential access

measurement, an alternative technique can be developed and adopted by cleaning and using the most accurate cadastral and address-based data, such as the UKBuildings data and the OS AddressBase Premium data. The cleaned datasets can be used as ancillary data of the alternative technique to disaggregate census data from the Output Area level to the household level so as to estimate population and measure potential access in a more accurate way. For integrating size, the size weighting of healthcare services can be calculated by dividing the Full Time Equivalent (FTE) physicians (an indicator used to measure availability) in each healthcare provision location by the total number of the FTE physicians in a city. To integrate the quality into spatial equity assessment, healthcare provision locations in a city can be classified into two categories for analysis, including all healthcare services in the city and healthcare services of good quality in the city in accordance with a certain quality criterion. Spatial equity can then be assessed based on the result of potential access measurement integrating the quality of healthcare services on the city scale (i.e. considering city as a platform).

1.2 Research Aim and Research Questions

1.2.1 Research Aim

The research aims to develop a GIS-based Spatial Equity Assessment Framework for guiding the measurement of potential accessibility integrating the size of healthcare services (i.e. potential access) and the assessment of spatial equity integrating the quality of healthcare services for social groups at the household level on the city scale (i.e. considering city as a platform).

1.2.2 Research Questions

1) How to disaggregate the lowest-level census data available to the household level using GIS?
2) How to measure potential accessibility to healthcare services integrating the size of the services (i.e. potential access) for social groups at the household level on the city scale?
3) How to assess spatial equity of healthcare services integrating the quality of the services for cities on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions)?
4) How to apply the GIS-based Spatial Equity Assessment Framework to provide policy recommendations for cities on the city scale?

1.3 Methodology - Case Study Approach

The research uses GP practices in Newcastle upon Tyne (hereinafter referred to as "Newcastle") as a case study. Newcastle is chosen as the case study city for the following reasons. First, the city has GP practices of different sizes (measured by the number of FTE GPs) and qualities (in accordance with the CQC ratings). Second, the city has a wide variation in deprivation and age groups in general, with higher concentrations of the Deprived Household (based on the 2011 Census Data deprivation data set) and Heavy User Group (age groups of 0-4 and over 74 with higher GP consultation rates) in several areas of the city. This is important because population classified by deprivation and age are chosen as the spatially defined social groups to measure potential access to GP practices and then to assess spatial equity based on the result of the measurement. Third, there is easy access to information and the site as the researcher is based in the city.

GP practices in Newcastle are used to illustrate and compare the application of the PWC technique and a proposed population weighting technique, the Household Space Weighting (HSW) technique using cadastral and address-based data as its ancillary data in population estimation inside Service Areas. GP practices in the city are also used to illustrate and compare the application of the HSW and PWC techniques in potential access measurement and illustrate spatial equity assessment using the result from the application of a more accurate potential access measurement method. The GIS-based Spatial Equity Assessment Framework is developed based on the above-mentioned potential access measurement and spatial equity assessment. Furthermore, the application of the assessment framework to provide policy recommendations is illustrated and summarized in the end of the case study.

1.3.1 Data Preparation

In order to illustrate and compare the HSW and PWC techniques in population estimation inside Service Areas, potential access measurement and spatial equity assessment in accordance with the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions), the following datasets and tools are required for analysis:

- ***Data Required***:

1) GP Practices by size (*the number of FTE GPs per GP practice*) and quality (*CQC ratings*)
2) 2011 Census Data (*population, deprivation and age datasets*)
3) Household Space (*OS AddressBase Premium* and *UKBuildings* datasets)

4) 2011 Output Area population weighted centroids
5) OS ITN Road and Urban Path Networks
6) Output Area boundaries
7) The boundary of Newcastle

- ***Tools Required***: ArcGIS, Excel and SPSS

Related databases are created following six steps. The first step is the creation of a database for GP practices in Newcastle by clipping the existing General Practice data (including the number of FTE GPs per GP practice dataset) by the boundary of Newcastle; updating the clipped data against the GP Practices A-Z Directory, NHS GP practice search online data and GP practice websites to incorporate the GP practice quality data (CQC ratings); and geo-editing the location of some GP practices updated against the OS MasterMap 1:1000 raster data downloaded from the DigiMap. The second step is the creation of a dataset using road and urban path networks data (OS ITN Road and Urban Path Networks) downloaded from the DigiMap and the identification of half a mile walking distance as the maximum walking distance threshold.

The third step is the creation of socio-demographic census database (i.e. population, deprivation and age) downloaded from the InFuse[2]. The fourth step is the creation of the database of residential buildings based on the AddressBase Premium data provided by the Ordnance Survey and UKBuildings data purchased from the GeoInformation Group. The fifth step is the creation of the boundaries of the city and the 910 Output Areas of the city downloaded from the Boundary Data Selector of the UK Data Service website[3]. The sixth step is the creation of database of the 2011 population weighted centroids of the 910 Output Areas of the city by downloading from the Office for National Statistics website[4].

1.3.2 Data Analysis

For data analysis, the research contains the following two phases using GP practices in Newcastle as a case study. In the first phase, the proposed HSW technique and the PWC technique are illustrated and compared in terms of population estimation inside the merged Service Areas of all GP practices in Newcastle. The purpose is to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas. Then, the two techniques are further compared in the

[2] http://infuse.ukdataservice.ac.uk/
[3] https://census.ukdataservice.ac.uk/get-data/boundary-data
[4] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html

context of the application of the PWC and HSW methods to measure potential accessibility and potential access (i.e. the percentage of potential accessibility to each GP practice multiplied by size weighting of each GP practice) to all GP practices in Newcastle. After that, the results of the application of the two methods are compared to demonstrate that the HSW method is more accurate than the PWC method in potential accessibility and potential access measurement.

In the second phase, the spatial equity assessment of GP practices in Newcastle is illustrated using the results from the application of the HSW method integrating the quality of GP practices based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). After that, the whole process is summarized from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework applying the HSW method. This leads to the development of the GIS-based Spatial Equity Assessment Framework. Also summarized is how to use the result from spatial equity assessment to provide policy recommendations on which GP practices may need to increase size and/or improve quality for cities on the city scale.

The HSW and PWC techniques and the HSW and PWC methods are applied based on the Network Analysis technique using half a mile as the maximum walking distance threshold. The HSW and PWC techniques are applied to estimate population inside Service Areas and the HSW and PWC methods are applied to calculate the number and percentage of potential accessibility and the percentage of potential access to all GP practices for the four variables representing social groups, i.e. Deprived/Non-Deprived Households (for the *equality* and *need* conceptions) and Heavy/Light User Groups (for the *equality* and *demand* conceptions) selected based on the conceptual framework.

For the PWC method, the *Have Their Centre In* criterion is applied using population weighted centroids to represent Output Areas, i.e. Output Areas with population weighted centroids located inside Service Areas are counted as with access, otherwise without access. For the HSW method, the cadastral and address-based population weighting technique is applied, i.e. Output Areas with all Household Spaces located inside Service Areas are counted as with full access, Output Areas with parts of Household Spaces located inside Service Areas are counted as with partial access, and Output Areas with no Household Space located inside Service Areas are counted as without access. For each Output Area with partial access, the weight of an Output Area is assigned in accordance

with the number of Household Spaces (calculated based on the number of Houses in Multiple Occupancy of residential buildings in use to represent the number of Households) located inside the overlap of the Output Area and the Service Areas divided by the total number of Household Spaces located inside the Output Area.

For both methods, the number of each social group with potential accessibility by Service Area in the city (the numerator) is calculated by multiplying the weight of each Output Area with access by the total number of each social group within the Output Area, and then adding up the results of all Output Areas with potential accessibility by Service Area in the city. The percentage of each social group with potential accessibility by Service Area in the city is calculated by dividing the numerator by the total number of each social group involved in the calculation of the numerator taking into account the overlay of Service Areas on the city scale. The percentage of potential access is then calculated based on the percentage of potential accessibility integrating the size of healthcare services (i.e. the size weighting) using the number of FTE GPs as an indicator to represent the size of GP practices.

It is worth noting here that as the size of GP practices (the measurement of *Availability* using the number of FTE GPs as the indicator) is incorporated into the analysis to measure potential access in a way that is closer to reality, it is necessary to take into account the overlay of different Service Areas in the measurement as well. Because apart from the size of GP practices, the location of population and social groups inside or outside the overlay of Service Areas can affect the level of potential access as well. Population and social groups located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003).

The second phase of the data analysis emphasizes spatial equity assessment and its application to provide policy recommendations. For the assessment of the *equality*, *need* and *demand* conceptions of spatial equity, the percentages of the Deprived and Non-Deprived Households and the Heavy and Light User Groups with potential access to all GP practices and GP practices of good quality by Service Area are compared respectively. The SPSS Mann-Whitney U is performed to test the difference when the percentage of potential access for the Deprived Households or the percentage of the Heavy User Group with potential access is higher than the percentage of potential access for the Non-Deprived Household or the percentage of the Light User Group. As SPSS

Mann-Whitney U tests only report results in a two-tailed manner, the median values of the percentages of the two groups under comparison by Service Area are compared by performing the Frequencies to determine whether there is an equitable, equal or inequitable access to healthcare services, drawing upon Nicholls' (2001) research. The Mann-Whitney U only tests the significance of the difference, which may be not enough for it only examines the likeability of the findings are due to chance, so the effect size was calculated to understand the magnitude of differences. The combination of statistical significance and effect size can help understand the full impact of a study (Sullivan and Feinn, 2012).

For the assessment of the *equality* and *need* conceptions of spatial equity, a *need-based equitable access* would be suggested when the percentage of the Deprived Household with potential access is significantly higher than the percentage of the Non-Deprived Household with potential access to healthcare services in a city; a *need-based equal access* would be suggested when the percentage of the Deprived Household with potential access is higher than the percentage of the Non-Deprived Household with potential access to healthcare services in a city while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *need-based inequitable access* would be suggested when the percentage of the Deprived Household with potential access is lower than the percentage of the Non-Deprived Household with potential access to healthcare services in the city on the city scale.

For the assessment of the *demand* conception of spatial equity, a *demand-based equitable access* would be suggested when the percentage of the Heavy User Group with potential access is significantly higher than the percentage of the Light User Group with potential access to healthcare services in a city; a *demand-based equal access* would be suggested when the percentage of the Heavy User Group with potential access is higher than the percentage of the Light User Group with potential access to healthcare services in a city while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *demand-based inequitable access* would be suggested when the percentage of the Heavy User Group with potential access is lower than the percentage of the Light User Group with potential access to healthcare services in the city on the city scale.

Finally, the whole process is summarized from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the

city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) applying the HSW method. This leads to the development of the GIS-based Spatial Equity Assessment Framework. Also summarized is how to use the result from spatial equity assessment to provide policy recommendations for cities on the city scale.

1.4 Research Findings

The research illustrated and compared the application of the HSW and PWC techniques to make population estimation inside Service Areas and the application of the HSW and PWC methods to measure potential accessibility and potential access. It then assessed spatial equity of GP practices in Newcastle on the city scale based on the result measurement of potential access to GP practices for social groups in the city at the household level on the city scale in accordance with the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions).

The difference in the results from the application of the HSW and PWC techniques in population estimation is largely due to different categorization of Output Areas with access that the two techniques adopt while making population estimation inside Service Areas. The PWC technique only divides Output Areas into two categories: i) Output Areas with full access when the population weighted centroids of the Output Areas are located inside Service Areas even though not all households within the Output Areas are located inside the Service Areas; and ii) Output Areas with no access when the population weighted centroids of the Output Areas are located outside Service Areas even though parts of households within the Output Areas are located inside the Service Areas.

In comparison, the HSW technique divides Output Areas into three categories: i) Output Areas with full access when all Household Spaces (to represent households) within the Output Areas are located inside Service Areas; ii) Output Areas with partial access when parts of Household Spaces within the Output Areas are located inside Service Areas; and iii) Output Areas with no access when no Household Space within the Output Areas is located inside Service Areas. For an Output Area with partial access, the weight is assigned in accordance with the number of Household Spaces (calculated based on the number of Houses in Multiple Occupancy of residential buildings in use) located inside the overlap of the Output Area and the Service Area dividing by the number of Household Spaces located inside the Output Area.

The different categorization of access between the HSW and PWC techniques results in that there are some Output Areas with population weighted centroids located inside Service Areas applying the PWC method (meaning with full access), while there are only parts of Household Spaces located inside the Service Areas (meaning with partial access) applying the HSW method; there are some Output Areas with population weighted centroids located outside Service Areas applying the PWC method (meaning with no access), while there are still parts of Household Spaces located inside the Service Areas (meaning with partial access) applying the HSW method. In other words, Output Areas involved in population estimation and the calculation of potential accessibility are signed with weights between '0'and '1' when applying the HSW technique rather than '0' or '1' when applying the PWC technique.

This is the source of aggregation errors caused by the application of the PWC technique, which leads to different results when joining with the 2011 Census Data to estimate population inside Service Areas and calculate the number of social groups with potential accessibility. The case study shows that the PWC technique produces inaccurate population estimation for 267 Output Areas (136 overestimations and 131 underestimations) out of 910 Output Areas in the city. The accuracy at the service area scale is important as the size (in terms of *availability*) and access of GP practices is normally investigated on an individual basis. The research has also demonstrated that the HSW technique is more accurate than the PWC technique in potential access measurement. When applying the two techniques to measure potential access to services taking into account the overlay of Service Areas, there are differences in the percentages of social groups with access at the Service Area scale. This could have policy implications if services with lower level of access by the disadvantaged social group would be selected to increase the level of access (e.g. through the increase of the size of the services).

On the city scale, the difference in the percentage of each social group with potential accessibility between the application of the HSW and PWC methods are larger than the difference in the number of each social group with potential accessibility. When calculating the denominator, the total number of each social group involved in the calculation of the number of each social group with potential accessibility in Newcastle on the city scale (the numerator) so as to calculate the percentage of potential accessibility, the PWC method does not take into account the number of each social

group in those Output Areas with population weighted centroids located outside Service Areas while with parts of the social group still located inside the Service Areas. Thus, there are underestimations of the denominators when applying the PWC method on the city scale. That is why the denominator applying the PWC method tends to be smaller than applying the HSW method. Thus, the percentage of each social group with potential accessibility applying the PWC method tends to be higher than applying the HSW method given the difference in the numerators between the application of the two methods is relatively small on the city scale. The percentage of each social group with potential access applying the PWC method tends to be higher than applying the HSW method as it is the percentage of each social group is multiplied by the size weighting of each GP practice on the city scale.

Therefore, even though the differences in the numbers of social groups with potential accessibility are small, the differences in the percentages of social groups with potential accessibility and potential access are large, with an absolute difference in the percentage of potential accessibility by 9-11% and a relative difference in the percentage of potential access by 18-22%. The large differences in the percentages are important because it is the percentages rather than the numbers of social groups with access that are comparable due to the difference in population size of each social group in a city.

Moreover, the research also demonstrates the necessity of including the *demand* conception in the spatial equity assessment framework in addition to the *equality* and *need* conceptions because the spatial equity assessment of all GP practices in Newcastle based on the *equality* and *need* conceptions (i.e. *need-based equal access*) is different from the result from the spatial equity assessment of all GP practices in the city based on the *equality* and *demand* conceptions (i.e. *demand-based inequitable access*). It also demonstrates the necessity of integrating the quality of healthcare services into the spatial equity assessment framework because the result from the spatial equity assessment of all GP practices in Newcastle based on the *equality* and *need* conceptions (i.e. *need-based equal access*) is different from the result of the spatial equity assessment of GP practices with good quality in the city based on the *equality* and *need* conceptions (i.e. *need-based inequitable access*).

1.5 Potential Contributions

The research may contribute to better measuring potential accessibility and potential access, and better assessing spatial equity of healthcare services in the following four

aspects. First, the HSW technique, a cadastral and address-based population weighting technique, can be applied to disaggregate the lowest-level census data available to the household level in a city using ancillary data reflecting the number of House of Multiple Occupancy of residential buildings in use to calculate the number of Household Spaces to represent the number of Households. In the case of the unavailability of the house level census data, this is a more accurate way to spatially disaggregate the lowest-level census data available to the household level as the exiting studies have not yet managed to disaggregate census data to this fine-grained level. The research argues for the use of the cadastral and address-based population weighting technique to replace the use of centroids (both geographical and population weighted centroids) to represent census units in access measurement (e.g. in the context of application of the *Have Their Centre In* criterion and 2SFCA method and its enhanced versions).

Second, the research demonstrates the application of a more accurate integrated availability and accessibility approach - the HSW method to measure potential accessibility and potential access, and then to assess spatial equity in accordance with the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). This leads to the development of a more comprehensive and accurate spatial equity assessment framework, the GIS-based Spatial Equity Assessment Framework. The assessment framework can be used to guide the measurement of potential accessibility integrating the size (i.e. potential access) of healthcare services in an absolute manner and the assessment of spatial equity integrating the quality of healthcare services for social groups at the household level on the city scale.

Third, the assessment framework can extend from healthcare services to other services in terms of spatial equity assessment. This can also better inform service planners and policy makers of priorities that could be given to services that may need increase size and/or improve quality in a more accurate way so as to help increase equitable access to those services. Fourth, the assessment framework can extend from potential access to realized access measurement if it is used by local councils as they may access individual level population data (or patient-level data). This can help local councils measure not only potential access but also realized access in a more accurate way.

1.6 Structure of the Thesis

The thesis is divided into eight chapters. Following this Introduction Chapter, Chapter Two and Chapter Three are Literature View Chapters, with the former focusing on

concepts and conceptualization such as equity, spatial equity, access and accessibility, and the latter emphasizing technical aspects of this research concerning potential access measurement such as GIS-based accessibility measures, issues and solutions, the measurement of potential access to healthcare services in the UK and beyond and major factors influence accessibility to healthcare services.

Chapter Four is Introduction to Case Study, which focuses on the healthcare system in the UK and the case study city of Newcastle and GP practices in the city. Chapter Five is Methodology where the whole design of the research is illustrated, and how related data is prepared and analyzed. It includes data preparation, justifications for variables and data used, data analysis, reflexivity on methodological and empirical limitations and further research.

Chapter Six and Seven are data analysis chapters using GP practices in Newcastle as a case study. Chapter Six illustrates and compares the HSW and PWC techniques to make population estimation inside Service Areas to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas. It then further illustrates and compares the HSW and PWC techniques in the context of the application of the PWC and HSW methods to measure potential accessibility and potential access to demonstrate that the HSW method is more accurate than the PWC method in potential accessibility and potential access measurement.

Chapter seven illustrates spatial equity assessment using the results from the application of the HSW method integrating the quality of GP practices based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) adopted in this research. After that, the whole process is summarized from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework applying the HSW method. This leads to the development of the GIS-based Spatial Equity Assessment Framework. Also summarized is how to use the result from spatial equity assessment to provide policy recommendations on which GP practices may need to increase size and/or improve quality for cities on the city scale.

The thesis is ended by the Conclusions Chapter. It focuses on an introduction leading to why choosing this research, research findings and importance to the existing studies, contributions of the research, and limitations and further research.

Chapter Two: Literature Review - Concepts and Conceptualization

2.1 Overview

There are two literature review chapters in this thesis. This literature review chapter focuses on concepts and conceptualization of equity, access and accessibility; the next literature chapter will emphasize technical aspects of accessibility and potential access. Through the review of literature in these two chapters, the conceptual framework of spatial equity will be developed drawing upon the existing studies, related terms will be defined, research gaps will be identified, and methods will be proposed to fill the research gaps.

The purpose of this chapter is to review the existing studies on *equity*, *spatial equity*, *access* and *accessibility* to develop the conceptual framework of spatial equity and define *potential accessibility* and *potential access* for this research. There are three sections in this chapter. The first section will illustrate the concepts of equity and spatial equity to develop the conceptual framework. The second section will focus on access and equity, which includes the taxonomic definitions of access, the dichotomous dimensions of access, the measures of potential access and realized access (utilization) and equitable access to healthcare services. The third section will emphasize accessibility, including the definitions of accessibility followed by potential and realized accessibility.

2.2 Conceptual Framework - Equity and Spatial Equity

Equity is "an issue of distributive justice", concerning "what is fair" (Lucy, 1981:448). Justice is a complex concept; there are various definitions largely due to its complexity. Miller (2003) quoted an old definition of justice given by the Roman Emperor Justinian that justice concerns how people should be treated equally unless there are justifiable reasons to treat them differently; there should be a justifiable proportionality of the inequality if they are treated differently.

Despite some consensus having been reached on 'equality', that is the "impartiality in the application of certain general rules allotting good or evil to individuals" (Sidgwick, 1981:140), there is still disagreement on the necessity and general principles for treating people differently in order to achieve social justice. For instance, the Classical Utilitarianism[5] mainly uses the notion of *justice* as a guide to measure utilities with

[5] It is a systematic theory, in various forms, that has long dominated modern moral philosophy and political thought, represented by Hume, Adam Smith, Bentham and Mill.

principles of achieving the greatest happiness, which holds that actions, laws, institutions, and so on can be judged in accordance with their inclination to maximize the total happiness of individuals, treating the happiness of each person equally (Sidgwick, 1981). While Rawls (1999) argues in the revised edition of his influential book titled *A Theory of Justice*[6] that all social values, such as liberties and opportunity, income and wealth in a society should be distributed equally unless an unequal distribution of any or all of these values are arranged to the greatest benefit of the least advantaged in the society.

The focus of the contemporary social psychology literature on distributive justice had been on the following three major principles of distribution before 1970s, *equity*, *equality* and *need* (Simpson and Varma, 2006). *Equity principle* refers to dividing resources (such as income, wealth and status) according to defined inputs (such as ability, intelligence and diligence), meaning that people who contribute more should receive more (Sampson, 1975; Wagstaff, 1994). *Equality principle* refers to dividing resources equally, meaning that people deserve an equal share regardless their differential inputs (Sampson, 1975). *Need principle* refers to dividing resources according to personal circumstances, meaning that the disadvantaged should receive more (Simpson and Varma, 2006). More recently, *equality* and *need principles* have emerged as more popular principles of fair or just distribution of services (Wagstaff, 1994).

In terms of the distribution of public services, *equity* is concerning "'Who gets what?' or, normatively, 'Who ought to get what?'", which involves "a multitude of value judgments about *who* should benefit" (the extent to which disadvantaged social groups should be spatially defined) (Wicks and Crompton, 1987:189). Besides, *equity* is also concerning "how the distribution can be measured?" which involves the methodology for distributing public services in an equitable way (Talen, 1998).

The just distribution of public services is a significant and challenging goal for planners as the realization of which can maximize equitable access to those services (Talen, 1998). In order to incorporate *equity* into planning process, Lucy (1981) relates the following five alternative concepts, *equality*, *need*, *demand*, *preferences* and *willingness to pay*.

[6] The book *A Theory of Justice* was started writing in late 1950s and largely written in 1960s based on the traditional theory of the social contract represented by Locke, Rousseau and Kant, with the first English version published in 1971. After the publication, Rawls received numerous comments and criticisms, based on which he revised and rewrote some parts of the book and had the revised English edition published in 1999.

Talen (1998) identifies four conceptions of *equity* that are relevant to planning for public services: *equality*, *need*, *demand* and *equity defined by market criteria*.

Equality describes that everyone should receive the same benefits from services, "regardless of socioeconomic status, willingness or ability to pay, or other criteria; residents receive either equal input or equal benefits, regardless of need" (Talen, 1998:24). However, the physical limitation (i.e. the impossibility to locate services equidistant to potential users) requires the adoption of threshold standards (e.g. using distance and/or density as the basis for location and size recommendations) to assess *equality* in the realm of public services (Lucy, 1981).

Need describes that each spatially defined disadvantaged social group should receive disproportionately more benefits from services (Talen, 1998). This is consistent with the idea that "unequals should be treated unequally", meaning "those needing more service should receive more, rather than less"; unequal treatment here requires "some defensible basis for the inequality", which requires the basis for identifying needs for social groups in accordance with their socio-economic status (e.g. households classified by deprivation) (Lucy, 1981:448-449).

Demand describes that an equitable distribution of services should be made taking into consideration the number and benefit of potential users, where "active participation in distributive decisions is 'rewarded' by increased user benefit" (Talen, 1998:24). This is manifested through the use of or request for services taking into account heavy and light users of the services, which requires the identification of social groups with higher and lower rates of usage, for instance social groups with higher and lower GP consultation rates classified by age in the context of primary healthcare services (Lucy 1981; Rogers et al., 1999).

Equity defined by market criteria describes that an equitable distribution of services should be made in accordance with market criteria. This makes the cost of services a key factor to determine the distribution of services, particularly when it comes to willingness to pay that reflects the extent to which people use specific services thus pay for them (Talen, 1998).

The term *spatial equity* refers to "the degree to which services or amenities are distributed in an equal way over different areas as well as economic, ethnic and political groups, with appropriate consideration given to the needs of special groups" (Omer, 2006:254-255). it

focuses on the socio-spatial dimension of *equity*, with an emphasis on determining what factors account for or are associated with spatial variations in service distribution (Omer, 2006). The evaluation of access to services is significant for the consideration of spatial equity issues -- "who has access to a particular service and who does not and whether there is any pattern to these varying levels of access" (Talen, 2003:182; Talen and Anselin, 1998). In socio-spatial terms, an inquiry about whether access to a particular service is equitable or not may require an investigation of "the extent to which there is a spatial pattern to varying levels of access and whether that spatial pattern varies according to spatially defined socioeconomic patterns" (Talen, 2003). The assessment of spatial equity is helpful for planners and policy makers to identify places where public services are inequitably provided, based on which decide where to provide new services and/or upgrade low quality services (Smoyer-Tomic et al., 2004; Taleai et al., 2014).

Out of the four conceptions related to *equity* identified by Talen (1998), it is argued that *equity defined by market criteria* is more related the economic dimension rather than socio-spatial dimension of *equity.* The measurement of access to services based on this conception could result in a conflict with the *need* conception, e.g. the conflict between the aggregate provision of services/efficiency and potential beneficiaries who are in greatest need (Figueroa et al., 2002; Talen, 1998). *Equality* is conflicted with *need*. Because *equality* describes that everyone should receive the same benefits from services regardless of socioeconomic status and other criteria, while *need* describes that each spatially defined disadvantaged social group should receive disproportionately more benefits from services (Talen, 1998). The physical limitation makes it impossible to locate services equidistant to potential users (Lucy, 1981). But with a certain distance threshold, *equality* can be assessed in the forms of *need-based equal access* and *demand-based equal access* (Nicholls, 2001).

However, the existing studies disproportionately focus on measuring access reflecting the *equality* and *need* conceptions (e.g. Boone, *et al.*; Chang and Liao, 2011; Comber *et al.*, 2008; Macedo and Haddad, 2015; Nicholls, 2001; Omer, 2006; Talen and Anselin, 1998), while ignoring the *demand* conception. The ignorance of the *demand* conception can lead to partial results in spatial equity assessment. Because even though there could be an equal or equitable access to services for the disadvantaged social group classified by an indicator reflecting needs in a city, there could be an inequitable access for the disadvantaged social group classified by an indicator reflecting demands in the city.

Therefore, the research will adopt the *equality (*in the forms of *need-based equal access* and *demand-based equal access)*, *need* and *demand* conceptions as its conceptual framework of spatial equity to assess spatial equity of services, with a special emphasis on healthcare services.

2.3 Access and Equity

2.3.1 Taxonomic Definitions of Access

There are various definitions of *access* in the health and healthcare related literature. *Access* could be viewed as "the availability of financial and health system resources in an area" (Aday and Andersen, 1974:209), or in terms of criteria such as cost, availability and internal characteristics (e.g. waiting time, delays and interruptions in receiving services) (Shortell, 1973) cited in Aday and Andersen (1974). *Access* could be defined that "services are available whenever and wherever the patient needs them and that the point of entry to the system is well-defined" (Aday and Andersen, 1974:209). From different perspectives, some researchers may refer *access* to the entry into or use of the healthcare system, while others may refer it to characteristics or factors that influence the entry or use (Penchansky and Thomas, 1981).

Drawing upon concepts relating to different dimensions of *access* identified by previous studies (e.g. *affordability* and *accessibility* by Bice *et al.* (1972), *availability* by Fein (1972) and Donabedian (1973), *acceptability* divided into *socio-organizational accessibility* and *geographical accessibility* by Donabedian (1973), *affordability* by Fein (1972), *availability*, *accessibility* and *accommodation* by Freeborn and Greenlick (1973)), Penchansky and Thomas (1981) propose a taxonomic definition of *access*. In this multi-dimension concept, *access* is "viewed as a general concept that summarizes a set of more specific dimensions describing the fit between the patient and the health care system", including *availability*, *accessibility*, *accommodation*, *affordability* and *acceptability* (Penchansky and Thomas, 1981:127). The five dimensions of *access* and their respective definitions can be referred to Table 1.

Table 1 The Five Dimensions and Definitions of Access

Concept	Definition
Availability	The relationship of the volume and type of existing services (and resources) to the clients' volume and types of needs. It refers to the adequacy of the supply of physicians, dentists and other providers; of facilities such as clinics and

	hospitals; and of specialised programs and services such as mental health and emergency care.
Accessibility	The relationship between the location of supply and the location of clients, taking account of client transportation resources and travel time, distance and cost.
Accommodation	The relationship between the manner in which the supply resources are organised to accept clients (including appointment systems, hours of operation, walk-in facilities, telephone services) and the clients' ability to accommodate to these factors and their perception of their appropriateness.
Affordability	The relationship of prices of services and providers' insurance or deposit requirements to the clients' income, ability to pay and existing health insurance. The clients' perception of worth relative to total cost is a concern here, as is their knowledge of prices, total cost and possible credit arrangements.
Acceptability	The relationship of clients' attitudes about personal and practice characteristics of providers to the actual characteristics of existing providers, as well as to provider attitudes about acceptable personal characteristics of clients. In the literature the term appears to be used most often to refer to specific consumer reaction to such provider attributes as age, sex, ethnicity, type of facility, neighbourhood of facility, or religious affiliation of facility or provider. In turn, providers have attitudes about the preferred attributes of clients or their financing mechanisms. Providers either may be unwilling to serve certain types of clients (e.g. welfare patients) or, through accommodation, may make themselves more or less available.

Source: Penchansky and Thomas (1981:128-129)

The five dimensions of *access* are separate, while there are no clear-cut boundaries between them (Penchansky and Thomas, 1981). For instance, *availability* is the basis for the analysis of the last four dimensions of *access* particularly *accessibility* in geographical or spatial terms. *Accessibility* is closely related to *availability* in some settings, but Service Areas of specific public services which have equivalent *availability* may have different level of *accessibility* as the populations located inside those Service Areas could be different. *Availability* undoubtedly has impacts on *accommodation* and *acceptability*, for example, when there is a high demand compared to supply, providers may offer services in different ways and have different abilities to select clients whom they would like to serve.

Regarding the measurement of access, the health-related literature is inclined to measure potential access while the planning literature has a tendency to measure potential accessibility. In the health-related literature, access to a certain type of healthcare services refers to the "availability of that service moderated by space, or the distance variable" (Khan, 1992:275). Thus, from a spatial perspective, access to healthcare services contains both *availability* (such as the number of physicians or the number of full time equivalent (FTE) physicians, e.g. Khan, 1992; Luo and Wang, 2003) and *accessibility* of services which requires the integration of the size of services (representing availability) into access measurement (Andersen *et al*., 1983; Khan, 1992). The integration of the size of services (in terms of *availability*) into the measurement of potential accessibility is potential access (Khan, 1992).

Although the existing methods in planning literature involve the measurement of the size of services located inside service areas for each demand point, the size that is measured in this context is more associated with the physical size of services (such as the area of public parks and the number of playgrounds, e.g. Comber *et al.*, 2008; Nicholls, 2001; Omer, 2006; Smoyer-Tomic *et al*., 2004; Talen *et al*, 1998; Talen, 2001). As this research intends to illustrate the measurement of access to services from socio-spatial perspective with the intension of extending from healthcare services to other types of public services, access will be measured in terms of *potential access*, i.e. *potential accessibility* integrating size in terms of *availability* rather than potential accessibility related to the physical size of services. Thus, *availability* and *accessibility* out of the five dimensions will be adopted in the spatial equity assessment framework that the research intends to develop.

2.3.2 Dichotomous Dimensions of Access

To better understand and measure access, a series of dichotomous dimensions have been identified to conceptualize *access* in the existing health and healthcare literature (Aday and Anderson, 1974). The first dichotomy is between *potential access* and *realized* (or *revealed*) *access* to healthcare services (Guagliardo, 2004; Khan, 1992).

Potential access is defined by Andersen (1995:4) as "the presence of enabling resources", which provides the means for and possibility of healthcare service utilization. Khan (1992:275) refers it to the "availability of that service moderated by space, or the distance variable". In this conceptualization, *access* is "the outcome of a process, determined by an interplay between the characteristics of the health care service system (e.g. the size and

distribution of health care facilities) and the characteristics of the population-at-risk in a specified area (e.g. age, health status, insurance coverage and income levels), and moderated by health care related public policy/planning efforts" (Khan, 1992:275).

Realized access (or *utilization*) is the actual use of services or actual entry into the healthcare system, the realization of which is dependent on the interplay between barriers and facilitators that reflect both potential users and the healthcare system (Anderson, 1995; Khan, 1992). When relevant facilitators overwhelm barriers, actual entry into the healthcare system is gained, thus *realized access* is achieved, and healthcare services are utilized (Khan, 1992).

The second dichotomy is between *spatial access* (or *geographical access*) which is associated with spatial aspects such as distance of potential users to healthcare services and *aspatial access* (or *social access*) which is associated with characteristics of population and healthcare services (Guagliardo, 2004; Joseph and Bantock, 1982; Khan, 1992). A typology of access may be useful to differentiate between *potential access* (*potential geographic access*) and *potential aspatial access* (or *potential social access*), and between *realized spatial access* (or geographical access) and *realized aspatial access* (or *realized social access*). This can be referred to a 2 x 2 matrix diagram (Figure 1) created by Khan (1992:276).

Figure 1 The Typology of Access

ACCESS DIMENSIONS	**Spatial (Geographic)**	**Aspatial (Social)**
Potential	Potential Spatial/ Geographic Access	Potential Aspatial/ Social Access
Realized	Realized Spatial/ Geographic Access	Realized Aspatial/ Social Access

Source: Reproduced from Khan (1992:276)

The third and fourth dichotomies are between *place access* and *population access* and between *pedestrian-oriented access* and *automobile-oriented access*. These two dichotomies of access are not much discussed in a clear term in the existing research despite their importance particularly in measuring access for certain social groups (Khan, 1992; Talent, 2003). The use of geographic centroids and population-weighted centroids to represent geographical or administrative units is an example of *place access* rather than *population access* particularly at the coarse scale (Talen, 2003). On the other hand, measuring access for residents or social groups rather than for geographical or

administrative units is an example of *population access* (*ibid*.). Thus, "weighting by population yields a measure of *population access*", while "not weighting by population yields a measure of *place access*" (Crawford, 2006:129).

The measurement of access for locally oriented populations (such as the elderly, the disabled and the poor) who rely on modes of transport other than the automobile is an example of *pedestrian-oriented access*, while for populations with private cars or public transport as modes of transport is an example of *automobile-oriented access*. Despite the importance of *pedestrian-oriented access* to healthcare services, the emphasis of the existing research is disproportionally placed on *automobile-oriented access* rather than *pedestrian-oriented access* to healthcare services (only a few, e.g. Todd *et al*., 2014; 2015). In practical terms, the choice between them may depend on the scale of analysis, whether at a regional scale or local scale; if access is in relation to features desired at a regional scale, "the maximum time-distance would be measured by the mode generally available to the persons in a locality"; if access is in relation to features expected to be available at a local scale, "maximum time distance would be measured by foot travel" (Lynch, 1984:202).

The third and fourth dichotomies could be added to the typology of access to provide an additional perspective for access analysis and measurement. It could be useful to identify the scale at which the *access* in question is measured, such as measuring access for places/statistical units (e.g. Output Areas) or residents/social groups; measuring access for residents/social groups relaying more on walking (or cycling) or automobile (private cars or public transport). The existing research focuses more on *spatial access*, *potential access* and *place access* rather than *aspatial access*, *realized access* and *population access*, which could be largely due to the absence of client-level data and census data at the fine-grained scale (Higgs and White, 2000; Joseph and Bantock, 1982). The emphasis of this research will be on the measurement of pedestrian-oriented population access and potential access using maximum walking distance as the distance threshold.

2.3.3 Measures of Potential Access and Realized Access (Utilization)

Among the above-mentioned four sets of dichotomies, the boundary between *potential access* and *realized Access* (*utilization*) is vague. This is because contact with and the utilization of healthcare services could form a continuum, thus access might refer to some point on this continuum (Figueroa et al., 2002). Figueroa *et al*. (2002:20) list the

following potential events concerning contact and utilization of healthcare services that may in fact indicate access to some point:

- "An individual resides a short distance from a health care setting;
- The individual becomes aware of his or her need for services;
- The individual becomes aware of the services provided by the health care setting;
- The individual establishes telephone contact with the health care provider;
- The individual establishes internet contact with the health care provider;
- The individual enters the health care setting;
- There is communication between the individual and a health care worker;
- There is communication between the individual and a health care worker in the language of the individual; and
- There is registration with a GP.

Thus, it is possible that residents have access to healthcare services due to the availability of such services, their awareness of the existence of the services and even registering with the services but without using them (Figueroa et al., 2002). Due to such vagueness, some measurements of utilization that have been used could be problematic. For example, contact rates with General Practitioners (GPs) have been used to measure utilization in primary healthcare services; but it may be not a good way to measure either the size or quality of healthcare services because contacts may only reflect administrative purposes in some circumstances such as the need for obtaining a sick note (Goddard and Smith, 2001). Besides, under-utilization of a specific type of healthcare service may indicate the use of its alternatives of similar type (or with similar services) or in its adjacent location. For instance, some residents may use alternative services in the private or voluntary sector, thus variations in utilization may not give a full picture of total use of services (ibid.). Instead of contact rates, consultation rates are used as an indicator of utilization (Blaxter, 1984; Carr-Hill, Goddard and Smith, 2001; Roger et al., 1999).

On the other hand, *potential access* to healthcare services has been measured using indicators such as the number of physicians or hospital beds per 1000 people. However, it is possible that a certain group of people have access to services (e.g. living within a certain distance threshold of the services) while do not use them (Figueroa et al., 2002). Thus, utilization rates have been suggested to measure potential access as an objective indicator although this may further blur the distinction between *potential access* and

utilization (ibid.). It is also suggested that the measure of potential access should reflect that residents falling into the category of population at risk use healthcare services at rates that are proportional and appropriate to their existing need for healthcare (Aday and Andersen, 1974; Freeborn and Greenlick, 1973). Thus, it could be more appropriate to measure potential access in a way reflecting the possibility of specific social groups in greater need of and demand for healthcare services to enter the healthcare system. This will be the focus of this research.

2.3.4 Equitable Access to Healthcare Services

The concept of equitable access to healthcare services has been a core objective of the UK's National Health Service (NHS) since its establishment in 1948 (Goddard and Smith, 2001). *Access*, whether it is defined in the dimension of healthcare service availability or in terms of healthcare service utilization is closely related to equity (Figueroa et al., 2002).

There is an extensive literature and government policies on equity in relation to health and healthcare services, which are written from various perspectives. For instance, Goddard and Smith's (2001) research focuses on equity in the form of equal access to healthcare services for people in equal need. This could be different from equality of treatment and equality of health outcome. Equal access for equal need could be more concerning that those with equal needs have equal opportunities to access healthcare services (Oliver and Mossialos, 2004). Equality of health outcome could emphasize more the relationship between the utilization and health outcomes from an equality perspective. Oliver and Mossialos (2004) summarizes the following three perspectives:

- "Equal access to health care for those in equal need of health care;
- Equal utilisation of health care for those in equal need of health care; and
- Equal (or, rather, equitable) health outcomes (as measured by, for example, quality adjusted life expectancy)".

Thus, there is no ubiquitously accepted definition and little agreement has been reached on the meaning of 'equitable access to healthcare services', let alone a comprehensive measurement (Oliver and Mossialos, 2004). Although this may diversify research related to equity and access to healthcare services (both potential and realized access), it may have caused difficulties in how 'equitable' access should be defined and how access to healthcare services should be measured so as to help achieve more equitable access. From

this perspective, it is necessary to understand whether access to healthcare services is equitable or not should be assessed based on a comprehensive equity assessment framework, and it is importance to have the framework in place to make such assessment. The development of a comprehensive spatial equity assessment framework is the main aim of this research. Within the framework, the *equality*, *need* and *demand* conceptions are adopted as the conceptual framework of spatial equity, which has been illustrated earlier in this chapter. The following subsection will focus on reviewing the existing studies on spatial equity of potential access to healthcare services in the UK context.

2.4 Accessibility

2.4.1 Definitions of Accessibility

There are various definitions of *accessibility*, which sometimes can be misused with other terms such as *mobility* that represents the ability to move from one place to another (Halden et al., 2005; La Rosa, 2014). According to Litman (2015:5), *accessibility* refers to "people's ability to use services and opportunities" including "goods, services, activities and destinations". *Accessibility* can be described as the ease with which services in one location maybe reached by population in another location via particular travel modes (Halden et al., 2005; Liu and Zhu, 2004; Nicholls, 2001). *Accessibility* can also be described as geographical barriers including "distance, transportation, travel time, and cost", which emphasizes the geographical location of services in association with population in need (Cromley and McLafferty, 2012:304).

In terms of measuring the 'ease', *accessibility* can be defined from the perspective of a given origin (i.e. *origin accessibility*) to measure the ease with which a specific group of people can reach a particular set of service, or from the perspective of a given destination (i.e. *destination accessibility*) to measure the ease with which a particular set of service can be reached by a specific group of people (Halden et al., 2005). Geographical barriers are related to transport barriers to access to services, which fall between the origin and destination. Halden *et al*. (2005:10) categorize transport barriers into six factors, including spatial, physical, temporal, financial, environmental and information, each of which contains two to three specific transport barriers to accessibility. Table 2 indicates the six factors and their corresponding transport barriers to access to services.

Table 2 Transport Barriers to Accessibility

Factor	Barrier
Spatial	Travel time including walk, wait, and in-vehicle in relation to time budget available
	Ability to interchange between all modes within integrated networks
	Availability of a route
Physical	Vehicle designs suitable for users e.g. low floor buses
	Kerb heights
	Topography
Temporal	Transport system and service reliability
	Waiting time/service frequency
	Scheduling of transport and activities
Financial	Travel cost
	Discounts for traveller groups
Environmental	Street lighting
	Interchange/waiting areas
	Safety/security
Information	Information prior to journey/skill level of travelers
	Information whilst travelling

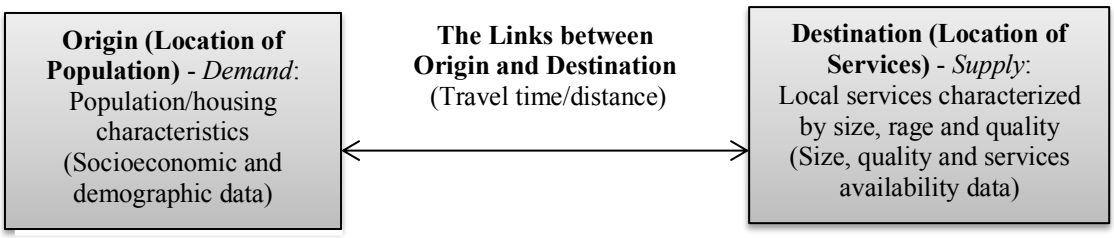
Source: Halden et al. (2005:10)

The geographical barriers mentioned above are roughly equivalent to the spatial factor of transport barriers to accessibility (travel time, travel cost, availability of routes related to distances) according to the categorization. According to the conceptual framework of spatial equity illustrated in the previous section, special consideration should be given to the spatially defined social groups in need and demand in overcoming geographical barriers to access services.

Various components make up *accessibility*. Among others, Halden et al. (2005:2) identify three primary components of accessibility, indicating that groups of individuals (population) have a range of service needs ('origin'), which can be met through services provided at various places ('destination'), with transport and communications (using indicators concerning travel time/distance) providing the links between the 'origin' and 'destination'. Talen (1998) summarizes three main variables involved in *accessibility*: 1) locational information (e.g. distance between population and services); 2) population/housing characteristics (e.g. socioeconomic data); and 3) characteristics of services (e.g. range of services available, and size and quality of services). Figure 2

demonstrates the three primary components of accessibility derived from the above illustrations.

Figure 2 The Illustration of the Three Primary Components of Accessibility



Source: Adapted from Halden et al. (2005) and Talen (1998)

Within healthcare research field, *accessibility* is concerning access to healthcare services, thus it is defined as the opportunity or ease with which potential users who are able to use appropriate healthcare services in relation to their needs (Daniels, 1982; Levesque et al., 2013:1; Whitehead, 1992). The definitions and dimensions of *accessibility* to healthcare services are summarized in Table 3 by Levesque *et al*. (2013:3).

Table 3 Definitions and Dimensions of Accessibility to Healthcare Services

Authors	Definition	Dimensions
Bashshur et al., 1971	Accessibility as the functional relationship between the population and medical facilities and resources, and which reflects the differential existence either of obstacles, impediments and difficulties, or of factors that are facilitators for the beneficiaries of health care	
Donabedian, 1973	Accessibility comprising the concept of degree of adjustment between resources and populations	
Salkever, 1976	Accessibility combining attributes of the resources and attributes of the population	Financial accessibility Physical accessibility
Aday and Andersen, 1974	Access as entry into the health care system	Predisposing factors Enabling factors Need for health care
Penchansky and Thomas, 1981	See Table 1	Availability Accessibility Accommodation Affordability Acceptability
Dutton, 1986	Utilisation viewed as the product of patients characteristics plus provider and system attributes	Financial Time Organizational factors

Frenk, 1992	Access as the ability of the population to seek and obtain care; Accessibility is the degree of adjustment between the characteristics of health care resources and those of the population within the process of seeking and obtaining care	
Margolis et al., 1995	The timely use of personal health services to achieve the best possible outcomes	Financial Personal Structural
Haddad and Mohindra, 2002	The opportunity to consume health goods and services	Availability Affordability Acceptability Adequacy
Shengelia et al., 2003	Coverage: probability of receiving a necessary health intervention, conditional on health care need; Utilization: quantity of health care services and procedures used	Physical access Resource availability Cultural acceptability Financial affordability Quality of care
Peters et al. 2008	Access viewed as including actual use of services. A clear emphasis is given to consider both users and services characteristics in evaluation of access. The notion of fit between users and services is identified.	Quality Geographic accessibility Availability Financial accessibility Acceptability of services

Source: Levesque et al. (2013:3)

Among the definitions summarized above, this research adopts the definition given by Penchansky and Thomas (1981:127) in relation to healthcare services that *accessibility* refers to the "relationship between the location of supply and the location of clients, taking account of client transportation resources and travel time, distance and cost". *Accessibility*, as one of the five dimensions of *access* in the context of healthcare services illustrated in the previous section, is affected by the way how access is categorized. The following are detailed discussions on *accessibility* in relation to the dichotomous dimensions of *access*.

2.4.2 Potential and Realized Accessibility

Accessibility is distinguished between *potential accessibility* and *realized accessibility* (e.g. Aday and Andersen, 1974; Andersen et al., 1983; Joseph and Bantock, 1982; Joseph and Phillips, 1984; Love and Lindquist, 1995). *Potential accessibility* is "an empirical representation that reveals degrees to which locational entities/resources are actually

accessed or engaged in interactions with origin entities" (Crawford, 2006:122-123). In the medical geography literature, it refers to the geographical or spatial relationship between healthcare services and residents in their surrounding areas (Love and Lindquist, 1995). *Potential accessibility* is related to the opportunity for residents to use healthcare services, which allows researchers to assess the nature and pattern of geographical or spatial access to healthcare services between potential users and healthcare services available over space (Martin *et al*., 2002; Higgs, 2004). Besides physical distance, as other major factors such as socio-economic factors (e.g. employment, income, education, housing, etc.) and demographic factors (e.g. age) also have impacts on the use of healthcare services (Love and Lindquist, 1995), it could be more appropriate to incorporate those additional variables into potential accessibility measurement.

Realized accessibility is related to the actual use of healthcare services (Martin *et al*., 2002). The examination of actual utilization patterns taking into consideration the factors mentioned above forms the basis for *realized accessibility* (Love and Lindquist, 1995). Thus, *realized accessibility* enables researchers to calculate the level of accessibility using healthcare utilization data of patients if patient-level data is available (Langford and Higgs, 2006).

There are various studies concerning *potential accessibility* and *realized accessibility*. For example, Joseph and Phillips' (1984) research applies a measure on potential physical accessibility based on the relative location of population and healthcare services using Canadian dataset to evaluate accessibility to GPs in rural areas of Canada. Lovett et al. (2002) employ vector-based GIS techniques combined with patient register data to evaluate accessibility to primary healthcare services in East Anglia of the UK.

The healthcare service system "adjusts its dimensions in response to the potential user dimensions, and makes services available", meaning "potential access is offered to potential users" rather than actual users of the services (Khan, 1992:275). However, in practice, due to the inaccuracy or absence of healthcare utilization data of patients, most studies have adopted potential approach based on either straight-line (buffers) or travel time distances (network analysis) between healthcare services and demand points in order to identify areas with inadequate provision of and access to healthcare services (Langford and Higgs, 2006; Lovett et al., 2002). More detailed review of literature on the measurement of potential accessibility and potential access will be provided in the next literature review chapter.

2.5 Summary

In this Literature Review Chapter, related concepts and conceptualization such as *equity*, *spatial equity*, *access* and *accessibility* were reviewed. Based on the review of the existing studies, the research adopted the *equality*, *need* and *demand* conceptions as its conceptual framework of spatial equity to assess spatial equity of services, with a special focus on healthcare services. The emphasis of this research will be on the measurement of pedestrian-oriented population access and potential access for social groups at the household level on the city scale based on the conceptual framework.

It is necessary to develop a comprehensive spatial equity assessment framework due to the absence of such assessment framework. The review of literature in this chapter forms the basis for the review in the next chapter on more technical aspects of this research, such as GIS-based accessibility measures, related issues and solutions, the measurement of spatial access to healthcare services, and major factors influencing potential access to healthcare services. A full summary of the two literature review chapters will be provided in the Summary of the next Literature Review chapter after reviewing the existing studies concerning technical aspects of the research.

Chapter Three: Literature Review - Potential Access Measurement

3.1 Overview

This is the second literature review chapter. The focus of this chapter is on reviewing the technical aspects of accessibility and potential access, such as GIS-based accessibility measures, the measurement of potential access in the UK and beyond and major factors influence potential accessibility. The purpose of this chapter is to identify research gaps and then propose methods for filling the research gaps.

The chapter is divided into four sections. The first section will focus on current debates on GIS-based accessibility measures, issues and solutions, with an emphasis on the applications of GIS, accessibility measures, the 'boundary issue' and its solutions such as the 'Coverage' method and the FCA methods, the aggregation error issue and ways to reduce aggregation errors in population estimation inside Service Areas such as using population weighted centroids and spatial disaggregation techniques. The second section will emphasize the measurement of potential access to healthcare services in the UK and beyond, including the regional availability approach, the regional accessibility approach, and the integrated availability and accessibility approach.

The third section will illustrate major factors that influence potential access to healthcare services, which will emphasize the socio-economic factor, the demographic factor, physical distance and urban form (urbanity/rurality). This chapter will be ended with a summary where research gaps will be identified, based on which how this research intends to fill the research gaps will be discussed briefly to form a basis for the Methodology Chapter.

Different types of services (including parks, playground, etc.) will be touched upon throughout this chapter when reviewing generic methods for measuring accessibility and when methodological issues are involved. Special emphasis will be placed on healthcare services in the UK and beyond particularly when it comes to the advancement of GIS-based approaches to measuring potential accessibility and potential access.

3.2 GIS-based Accessibility Measures, Issues and Solutions

3.2.1 Applications of GIS

The quantitative evaluation of *spatial equity* is frequently achieved by measuring accessibility to services employing accessibility measures (Smoyer-Tomic et al., 2004; Taleai et al., 2014; Talen and Anselin, 1998). As accessibility measurement involves

extensive spatial analysis of services as well as socio-economic and demographic data that requires a large amount of computation, Geographical Information System (GIS) technology has been used widely over the past decades (Liu and Zhu, 2004).

GIS is a powerful tool to make accessibility analysis of both spatial and non-spatial data, which enables the integration of multiple datasets such as socio-economic, demographic, transportation, land use and services (Langford et al., 2007; Liu and Zhu, 2004; Parker and Campbell, 1998). Meanwhile, the modeling of accessibility has developed significantly due to the development of GIS functions particularly the GIS network analysis modules, such as ArcGIS Network Analyst (La Rosa, 2014; Nicholls, 2001; Smoyer-Tomic, 2004). This enables the integration of socio-economic data and road networks/urban paths data into more advanced methods so as to enhance accessibility analysis, such as measuring travel times under different transport or network scenarios in order to investigate spatiotemporal variations in accessibility (Higgs, 2004; Pham et al., 2012; Sander et al., 2010).

Thus, GIS is an appropriate tool to be used to analyze accessibility for health-related purposes (Parker and Campbell, 1998). Early applications of GIS in the health-related research field centered on epidemiological issues as GIS has a logical fit in many epidemiologic studies which is about the distribution and determinants of diseases and injuries in groups of people (Moore and Carpenter, 1999; Nicol, 1991). More recently GIS has been applied in the planning and management of healthcare services (Parker and Campbell, 1998).

In terms of GIS-based studies on measuring accessibility to services, apart from the focus on measuring accessibility to multiple services at one spatial scale (For example Apparicio and Seguin (2006) and Taleai *et al.* (2014)), the majority of the existing studies emphasize measuring accessibility to one particular type of service, such as parks and greenspaces (e.g. Boone et al., 2009; Chang and Liao, 2011; Comber *et al.*, 2008; Higgs *et al.*, 2012; Lindsey et al., 2001; Nicholls, 2001; Omer, 2006; Talen, 1998; Pham et al., 2012), schools and playgrounds (e.g. Smoyer-Tomic, 2004; Talen and Anselin, 1998), supermarkets and food stores (e.g. Apparicio et al., 2007; Farber et al., 2014) and healthcare services (e.g. Delamater, 2013; Delamater et al., 2012; Fransen et al., 2015; Green et al., 2012; Langford, et al., 2016; Lovett et al., 2002; Wang, 2012; Wood *et al.*, 2004) at one spatial scale.

In the following subsections, different types of services mentioned above will be touched upon when generic methods for measuring accessibility and methodological issues are involved. Special emphasis will be placed on healthcare services when it comes to the advancement in GIS-based approaches to measuring accessibility.

3.2.2 Accessibility Measures

There are various accessibility measures that have been used in the existing studies, from a traditional measure based on a simple count of services within a certain areal unit to a potential measure based on the gravity model to average travel cost and to minimum distance. Table 4 illustrates the five most widely used GIS-based measures for assessing accessibility to services, which focuses on services in general and only touching upon healthcare services when necessary. The measurement of potential access (involving both *availability* and *accessibility*) to healthcare services will be reviewed separately in detail later in the section of Measurement of Potential Access to Healthcare Services.

Table 4 GIS-based Accessibility Measures

Name	Expression	Standard Approach
'Container' Measure	Formally, a 'Container' index Z_i^C for location (tract) *I* is expressed as: $\boldsymbol{Z_i^C} = \sum_j S_j \ , \forall j \in I$ Where, the number or aggregate size of S_j is added up for the services located within the boundaries *I* of *i*.	In which the number of services contained within a given geographical or administrative unit (e.g. ward and census tract)
'Coverage' Method	Adapted from the 'Container Measure', where coverage is sometimes referred to as the `cumulative opportunities' of a given location.	In which a certain critical distance or covering radius is defined, and a correlation coefficient is applied to identify the quantity or size of services that are included within the covering radius (or the Service Area) for each demand point (those located within the critical distance or covering radius are counted as with access, otherwise without access)
Gravity Model	Formally, a Gravity index Z_i^G is expressed as:	In which public services are weighted by their size and

	$\boldsymbol{Z_i^G} = \sum_j \frac{S_j}{d_{ij}^{\alpha}}$ Where, S_j *is* the size of each service at its location *j*, d_{ij}^{α} is a distance decay factor, with distance d_{ij} between tract *i* and service *j*, and friction parameter α.	adjusted for the frictional effect of distance (The model is based on an analogy with Newtonian physics; a related concept of gravitation is gravitational potential)
Minimum Travel Cost measure (Adapted from locational optimization models)	Formally, a Minimum Travel Cost index Z_i^T or $\overline{Z_i^T}$ is expressed as: $\boldsymbol{Z_i^T} = \sum_j d_{ij}$ Or, $\boldsymbol{\overline{Z_i^T}} = \sum_j \frac{d_{ij}}{N}$ *Where,* d_{ij} is the distance between a residential location *i* and service *j,* and *N* is the total number of facilities.	In which the minimum or average distance between each origin (e.g. census tracts) and each destination (e.g. public services) is simply measured
Minimum Distance measure/Equity Model	Formally, a Minimum Distance index Z_i^E is expressed as: $\boldsymbol{Z_i^E} = \min_j \lvert d_{ij} \rvert$ Where, d_{ij} is the distance between a residential location *i* and service *j*.	In which a location that reduces the longest journey of any origins (e.g. census tracts) to a minimum level is chosen to minimize inequality (Accessibility is inversely related to this measure)

Source: Adapted from Geertman et al. (1995); Omer (2006); Talen (1998); Talen and Anselin (1998); Talen (2003)

The choice of a particular accessibility measure depends on specific goals of a study and characteristics of services involved (Higgs et al., 2012; Talen, 1998; Talen and Anselin, 1998). If the aim of a study is to assess whether the distribution of services is equitable or not, it may be essential to decide what accessibility measure to apply based on what type of service it is, at what scale an analysis will be made and limitations of each measure (Talen and Anselin, 1998). For instance, if a certain service is highly localized (such as playground or community library), then the Minimum Distance measure could be more appropriate particularly at a larger scale of analysis, as the assumption of this measure is that residents are inclined to use services closest to their residential locations. The 'Container' Measure could also be appropriate in this case if the sphere of influence of

this service is limited to a specific geographic unit smaller than the scale of analysis, as it assumes that residents only use services located within the boundary of their neighborhoods.

On the other hand, if the sphere of influence of a certain service is across a larger scale exceeding the boundary of a specific geographic or administrative unit such as wards or census tracts, then the Minimum Travel Cost measure could be more appropriate. Because it calculates the total or average distance from origin (residential locations) to destination (services) with the assumption that residents can travel to any services regardless of their distances within a city. Gravity Model could also be appropriate in this case, as it also assumes that residents can travel to any services within a city although they are less likely to travel to further locations.

From the perspective of analyzing spatial externalities, in general, the Gravity Model and Minimum Travel Cost Measure capture the spatial externalities of services, with the former having a sharper decay of distance; while the Minimum Distance measure is another extreme, which captures no spatial externalities, as it calculates only one service within the minimum distance from a certain residential location at a time (Talen and Anselin, 1998). As to the 'Container' Measure, the extent to which the spatial externalities are included depends on the scale of critical distance or covering radius involved: there could be no spatial externalities involved according to its assumption (Nicholls, 2001), while with spatial externalities included in a limited manner when there are multiple services located within the radius (e.g. wards or census tracts) (Talen and Anselin, 1998).

3.2.3 The 'Boundary Issue'

Apart from the appropriateness of the accessibility measures in the 'scope of application' according to the type of services and scale of analysis, it is also necessary to understand their limitations or problems. As mentioned earlier, it could be appropriate to adopt the 'Container' Measure when the Service Area of a certain service matches the geographical unit that is involved in the analysis. However, the exclusion of spatial externalities to other geographical units by applying the 'Container' Measure can cause problems when the scale of analysis exceeds the geographical or spatial unit under analysis, i.e. the 'boundary issue'.

For instance, in the case of accessibility analysis of services such as libraries and hospitals, residents cannot be excluded from using these services located outside the

census tracts or ward of their residential locations (Talen and Anselin, 1998) let alone even smaller spatial scales of analysis, such as Super Layer Output Areas (SLOAs with roughly 1500 residents or 650 households each) and Output Areas (OAs with roughly 300 residents or 160 households) in the UK context. A major disadvantage of the 'Container' Measure is that it does not take into account the spatial distribution of opportunities (Nicholls, 2001). For this reason, the assumption of the 'Container' Measure has been challenged as unrealistic in the existing studies (for example Hewko et al. (2002) and Zhang et al. (2011)).

In order to overcome the above-mentioned 'boundary issue' in employing the 'Container' Measure, there are two types of attempts, one is in the planning literation and another one is in the medical geography literature. The former adapts the 'Container' Measure to 'Coverage' method and the latter adopts the FCA methods. The two attempts will be illustrated in the following two subsections.

3.2.4 Solution to the 'Boundary Issue' - 'Coverage' Method

Instead of counting the number or size of services within a certain administrative or spatial unit as in the 'Container' Measure, the 'Coverage' method is measured by the size of services available for the population within a certain critical distance or covering radius (e.g. Comber *et al.*, 2008; Nicholls, 2001; Omer, 2006; Smoyer-Tomic *et al.*, 2004). Omer's (2006) research adapts the traditional aggregated 'Container' Measure to the 'Coverage' method using house-level census data to calculate the area of public parks available for each house within the park's coverage areas (buffers or circles surrounding parks' perimeter using Euclidian Distance) to measure accessibility to those parks.

The 'Coverage' method takes spatial dimension into account, which is represented originally by drawing a circle around a certain service (supply side) against "a radius equivalent to the maximum desired distance of users from it"; populations 'covered' by or located within the radius are counted as with access (Nicholls, 2001). The 'Coverage' method does have advantages in measuring accessibility as it takes into consideration spatial distribution of opportunities (e.g. the spatial influence of a specific service on population within a certain radius), but it has a usage problem concerning how the coverage area is created. Drawing a circle against a certain radius to represent a coverage area cannot reflect the reality since the assumption that potential users of services travel in straight lines is not realistic.

In reality, potential service users may need to travel via road networks and/or footpaths to access services. To overcome this problem, the 'Coverage' method has been improved by using Network Distance instead of Euclidian Distance. For example, Nicholls' (2001) study employs GIS-based Network Analysis using road data to measure accessibility to public parks, the result of the measurement is then compared to the result using Euclidian distance. The study's main focus is to measure accessibility to public parks within walking distance of people's residence (half a mile was chosen as the maximum walking distance threshold) using geographic centroids of Census Block (the lowest statistical unit in the US) to represent population locations. Comber *et al.*'s (2008) research employs Network Analysis to measure accessibility to services, taking into consideration road networks. The research calculates the number and percentage of social groups (taking ethnic and religious groups as examples) with and without access based on Network Distance calculation from geographic centroids of the Output Areas (representing population locations of the lowest statistical unit in the UK) to the access points of urban greenspaces to measure accessibility.

In the context of healthcare services, traditionally, catchment areas are created based on straight-line or travel time/distance around demand points (i.e. healthcare delivery points) instead; within catchment areas, the population or its subgroups are estimated by employing areal interpolation techniques, such as point-in-polygon analysis that uses simple geographic or population weighted centroids (demand points) to represent census units (Langford and Higgs, 2006). In the absence of census data at fine-grained scales, researchers often resort to using population weighted centroids within communities to represent population locations (Higgs and White, 2000). However, the population weighted centroid is a single summary reference point of a census unit (ONS Website, 2016). The aggregation error issue still exists due to the use of single points to represent polygons (e.g. census units) (Smoyer-Tomic *et al.*, 2004) when it is combined with the application of the *Have Their Centre In* criterion (i.e. calculating the population inside census units with census centroids located inside catchment areas) to measure access (Nicholls, 2001). This will be discussed in detail later in the Aggregation Error Issue section together with other associated problems in relation to the use of other areal interpolation tools such as dasymetric mapping techniques.

3.2.5 Solution to the 'Boundary Issue' - Floating Catchment Area Methods

Another attempt is the broadening of the accessibility measure to assess accessibility continuously over space within a city (Nicholls, 2001; Talen and Anselin, 1998). One example is the 2-Step Floating Catchment Area (2SFCA) method, an approach introduced by Luo and Wang (2003) building on Radke and Mu's (2000) research derived from the Gravity Model to measure accessibility based on the interaction between travel-time catchment areas of the supply and demand points.

The 2SFCA method uses travel time/distance floating catchment areas rather than fixed geographic/spatial or administrative boundaries, which contains two steps. The first step is calculating the supply-to-demand ratio for each healthcare service (*j)* by dividing the number of supply by the sum of people that are within each catchment area of the healthcare service created based on a certain threshold distance (*d*). The second step is summing up all the R_j values for all healthcare services inside the catchment areas created based on population locations. The final accessibility value (A_f) represents the balance between the availability of a specific type of healthcare service (e.g. represented by the physician-to-population ratio) and accessibility to the healthcare service (e.g. represented by the sum of all supply points within a given travel-time distance of all demand points); higher values stand for higher level of accessibility (Langford and Higgs, 2006). Luo (2004) applies the 2SFCA method to examine the primary healthcare physician shortage conditions in nine counties surrounding DeKalb in northern Illinois. Wang and Luo (2005) further illustrate the application of the 2SFCA method by integrating both spatial and aspatial factors to measure accessibility to primary healthcare services in the State of Illinois. The research uses physicians and population-weighted centroids of census tracts to create catchment areas for demand points using a 30-minute threshold against travel speeds based on road classification and urban/suburban/rural differentiation.

The 2SFCA method provides a substantial theoretical advantage compared to the 'Container' Measure by allowing the containers to "float" as catchment areas that are created based on distance or travel time from supply and demand points (Delamater, 2013). However, due to the unavailability of house-level census data, it has problems with obtaining population counts inside catchment areas to be used to calculate the physician-to-population ratio and then to measure potential access (availability and accessibility) (Higgs, 2004). In the absence of higher resolution census data, there are two

commonly used techniques to estimating population inside catchment areas in the existing studies, that is calculating the population inside census units with their centroids located inside catchment areas (i.e. *Have Their Centre In* criterion) or by the proportion of the census unit intersected with catchment areas (i.e. areal weighting technique) (Nicholls, 2001; Smoyer-Tomic *et al*., 2004).

However, both techniques used in the 'Coverage' method and FCA methods cause aggregation errors as the former only estimates either the total population (if centroids located within) or no population inside catchment areas (if centroids located outside); the latter has the same problem if it uses the *Have Their Centre In* criterion or assumes that population are evenly distributed across census units if it applies the areal weighting technique (Higgs, 2004). There are other methods, such as dasymetric mapping technique that could provide more accurate population estimation than the above two techniques (Langford and Higgs, 2006) although they still cause aggregation errors. The aggregation error issue and population estimation techniques will be discussed in detail in the following subsections.

3.2.6 Aggregation Error Issue

For various reasons or purposes (e.g. confidentiality and data dissemination), population are often aggregated into administrative of spatial/geographical units, such as neighborhoods or certain types of census units to represent the distribution of population and its subgroups in residential areas (Apparicio et al., 2008; Hewko et al., 2002; Langford *et al*., 2007). As socio-economic data is normally collected and reported at a spatially aggregated level as mentioned above, the occurrence of aggregation errors is inevitable particularly where population distributions are aggregated to larger geographical or spatial units (Li et al., 2007). Thus, aggregation error is a generic issue in employing accessibility measures, which is sometimes called the Errors-in-Variables Bias in the health and healthcare literature (Fortney *et al*., 2000; Love and Lindquist, 1995).

As a generic issue, the aggregation error is related to several other concepts (i.e. *scale*, *extent* and *grain*) that are associated with population representation, scale of analysis and potential accessibility measurement. It could be helpful to illustrate these related concepts before continuing the discussion on the aggregation error issue. Spatial representation and the scale of analysis are important since they impact potential accessibility measurement in applied projects to measure potential accessibility which represents the interaction between the location of potential users and services as a distance-based concept

(Crawford, 2006). *Scale* is most frequently referring to the two primary components - *extent* and *grain*, which is related to how spatial entities are represented within a GIS environment in geographic information science (Goodchild, 2011; Wu and Li, 2006).

Both *extent* and *grain* are important to the study of heterogeneous landscapes (Wu and Li, 2006), of which *extent* refers to the "size of the study area or the duration of time under consideration", and *grain* refers to the "finest level of spatial resolution possible with a given data set" (Turner et al. 1989:246). Concerning *extent*, a variety of the existing accessibility research focuses on intra-metropolitan extents in the case of urban study areas or regional extents in the case of rural study areas; as to *grain*, the existing research typically uses census-defined spatial units (hereinafter referred to 'census unit') of different scales (Crawford, 2006), such as wards, LSOAs and OAs in the UK context, or counties, block groups and blocks in the US context. The majority of existing studies use centroids to represent the above-mentioned census units, which results in aggregation errors as they treat the entire population of census units as if they ignore the uneven distribution of population throughout the census units at varying densities, and/or ignore the heterogeneity of the population within census units (Crawford, 2006; Hewko et al. 2002; Knox, 1979).

The aggregation-error issue is evident when distance calculation between spatial units is involved, as those spatial units are often represented by a single point or centroid (e.g. the un-weighted geographic centroid) of a polygon (Hewko et al., 2002). Aggregation errors are particularly pronounced when centroids are used to represent residential geographical locations on coarse grains as it assumes that populations in those coarse scale spatial units are evenly distributed and homogeneous (Apparicio et al., 2008; Smoyer-Tomic *et al.*, 2004). Apparicio, et al.'s (2008) research compares aggregation errors caused by the use of census tract centroids (the least accurate aggregation method), population-weighted mean of the accessibility measure for dissemination areas within census tracts and population-weighted mean of the accessibility measure for blocks within census tracts (the most accurate method). The result of the research indicates the difference in measurement errors by 5% to 10% from the least aggregation accurate method to the most accurate aggregation method for the healthcare services selected in the research. The results from the Spearman rank correlations between measures of the accessibility of hospitals by aggregation method suggests that "it is preferable to use an aggregation method that precisely accounts for the distribution of population within it".

However, geographic centroids are widely used in the existing research, the majority of which make spatial analysis on coarse grains, such as the census block in Nicholls's (2001) study and the Output Area in Comber et al.'s (2008) study. This will be further discussed in the following subsections.

3.2.7 Reducing Aggregation Errors – Population Estimation inside Service Areas Using Spatial Disaggregation Techniques

As accessibility measured using smaller census units is less subject to aggregation errors, studies have focused on investigating finer-grain census data to make population estimation inside Service Areas so as to measure accessibility in a more accurate way (e.g. Apparicio et al., 2008; Fortney et al., 2000; Hewko et al., 2002; Landry and Pu, 2010; Omer, 2006; Pham et al., 2012; Li *et al*., 2014; Troy, 2007). For instance, Omer's (2006) research uses high-resolution census data, the house-level socio-economic and demographic data in Tel Aviv, Israel due to the availability of that fine-gain census data in the city (despite needing to overcome data usage issues). The research improves the accuracy of accessibility measurement and spatial equity assessment. However, house-level census data is not available in most countries.

Due to the lack of house-level census data, the United States and Canada typically use the census tract or block group aggregation as the lowest statistical unit of analysis (grouping an average of 600 and 5000 residents respectively) (Apparicio, et al., 2008; Hewko, et al., 2002; Heynen et al., 2006; Landry and Chakraborty, 2009; Tooke et al., 2010; Troy et al., 2007). The UK uses Output Areas as the smallest census unit aggregation for the lowest scale of analysis (grouping approximately 300 residents) in accessibility measurement (Comber et al., 2008; Higgs, et al., 2012). The above-mentioned scales of aggregation could cause aggregation errors, as socio-demographic characteristics of population living in a census tract/block group and Output Area could be unevenly distributed and heterogeneous; even if residents are relatively homogenous, the heterogeneity of the physical environment, particularly the built environment and open spaces could be lost at these coarse scales of aggregation (Maantay et al., 2007; Pham et al., 2012).

As the lower the level of disaggregation, the higher the level of precision in accessibility measurement (Talen, 2003), a few studies intend to investigate different disaggregation techniques to disaggregating the socio-demographic data from the smallest grain available to even finer grains so as to provide more accurate population estimation or reducing aggregation errors (e.g. Boone, 2008; Boone et al., 2009; Li *et al*., 2007;

Maantay *et al*., 2007; Pham *et al*., 2012). In general, the accuracy depends primarily on appropriateness of the assumptions based upon and the geography of case studies in question (Li *et al*., 2007). Li *et al*. (2007) summarize the assumptions, methods and data required for the most commonly used disaggregation techniques, which can be referred to Table 5.

Table 5 The Comparison beween Major Disaggregation Techniques

Technique	Method	Assumption	Control Surface (Ancillary Data Required)
Simple Areal Weighting	Cartographic	Homogeneous source zones	None
Regression Model	Statistical	Source zone composed of land classes with global uniform density	Discrete or Continuous
Binary Dasymetric Mapping	Cartographic	Source zone composed of populated and unpopulated areas	Discrete (binary)
Three-Class Dasymetric Mapping	Cartographic	Homogeneity at different land class (at each source zone)	Discrete
EM Algorithm	Statistical	Source zone composed of land classes with global uniform density that conserve aggregate value	Discrete or Continuous

Source: Adapted from Li *et al*. (2007:2)

However, apart from advantages in various aspects, all disaggregation techniques inevitably generate errors as there are limitations associated with the assumptions that they are based on. Some errors may be caused by assumptions concerning the spatial distribution of the entities (such as homogeneity in density), while others may be caused by assumptions about spatial relationships assumed for spatial disaggregation procedures (Li *et al*., 2007). Maantay et al. (2007) review the advantages and limitations of nine disaggregating techniques, including the *Areal Interpolation*, *Filtered Areal Weighting (Binary Method)*, *Land Use/Land Cover as Ancillary Data*, *Three-Class and Limiting Variable Methods*, *'Image Texture' Method*, *Statistical Approaches – Regression-based Analyses*, *Heuristic Sampling Method*, *Kernel Density Surface from Population-weighted Census Centroids* and *Use of Other Types of Ancillary Data – Street-weighted Interpolation*. On the basis of the reviewing and comparison between the nine existing

techniques, the research demonstrates that population weighting techniques are more accurate than areal weighting techniques. The research then proposes a more advanced population weighting technique, the Cadastral-based Expert Dasymetric System (CEDS), which will be discussed in detail later in this section.

Concerning the application of disaggregation techniques and the comparison between them, Li *et al*. (2007) compare the four disaggregation techniques, the Binary Dasymetric Mapping, Regression Model, Locally Fitted Regression Model and Three-class Dasymetric Mapping to identify their comparative accuracies. The result of the comparisons indicates that the Three-class Dasymetric Mapping technique produces higher level of accuracy compared to the other three disaggregation techniques (Li *et al*., 2007). However, the assumption of the technique is the homogeneity at different land class (at each source zone) (ibid.). Boone's (2008) research disaggregates census data by overlaying census tracts with land use information using dasymetric mapping approach, through which census data is partitioned into land use data, thus identifying residential areas from the land use information. Pham et al.'s (2012) research further disaggregates census data taking into consideration the built environment, such as buildings, alleys and yards of residential parcels from satellite images.

The CEDS technique proposed by Maantay *et al*.'s (2007) research mentioned above focuses on mapping population distribution in the urban environment using cadastral data as its ancillary data. The technique uses Residential Areas and the number of Residential Units as proxies for population distribution with the assumption that the areas with more potential living accommodations have larger population. The difference between the CEDS technique and the other forms of dasymetric mapping techniques mentioned above is that it does not use areal weighting or the binary method; it uses detailed cadastral data as its ancillary data rather than using remotely sensed land cover/land use data to estimate population density classes (Maantay *et al*., 2007). The research compares the application of the CEDS and the Filtered Areal Weighting techniques in estimating population through a case study of asthma hospitalization. In the case study, census block group population is disaggregated to the Tax-Lot level, assigning the value '1' to the Lots with centroids located inside the target area and '0' to the Lots with centroids located outside the target area before calculating and summing up associated populations.

The result shows that the CEDS technique is more accurate than the Filtered Areal Weighting technique in population estimation inside targeted areas. However, the use of

the geographic centroids to represent Tax-Lots while applying the CEDS technique still cause aggregation errors, which will be discussed in a more detailed way in the next subsection.

3.2.8 Reducing Aggregation Errors – Population Estimation inside Service Areas Using Population Weighted Centroids

To better estimate population inside Service Areas, population weighted centroids are introduced to replace geographic centroids (e.g. Higgs and White, 2000; Wang and Luo, 2005). The population weighted centroid represents "the spatial distribution of the population in each instance of its geographies, as recorded in the 2011 Census, as a single summary reference point on the ground"; "each population weighted centroid was calculated using a median centroid algorithm, the result of which is less influenced by outliers than the result of an algorithm to calculate the mean centroid" (ONS, 2013).

Population weighted centroids are used in the UK's policy documents, such as the *IMD 2015* (DCLG, 2015) and the *SIMD 2012* (The Scottish Government, 2012). Take the *IMD 2015* for example, population weighted centroids are used in the *Geographical Barriers* sub-domain to represent Output Areas to calculate their Average Road Distances to local key services so as to measure Mean Distances from LSOAs (within which the Output Areas are located) to the local key services. The population weighted centroids of the LSOAs are used as their proxies when calculating the Mean Distances to measure accessibility to local key services.

The replacement of geographic centroids by population weighted centroids could make the representation more accurate and closer to reality as the median centroid algorithm used in the calculation takes into consideration the location of households (ONS, 2013). However, despite the above-mentioned advantage in using population weighted centroids over geographic centroids, the aggregation-error issue still exists due to the use of single points to represent polygons (census units) (Smoyer-Tomic *et al*., 2004) when it is combined with the application of the *Have Their Centre In* criterion (Nicholls, 2001) (i.e. the Population Weighted Centroid (PWC) technique) to measure potential access to services.

The disaggregation techniques reviewed in the previous subsection and population representation techniques reviewed in this subsection have been proposed based on a common assumption, that is the absence of the spatial data concerning the location of socio-demographic data (or census data) at the house level. However, with the updating

of more accurate cadastral and address-based data such as the UKBuildings data and the OS AddressBase Premium data in the UK context, there could be an alternative technique to identify the location of households within census units, thus further reducing aggregation errors by replacing the use of centroids (both geographic and population weighted centroids) to represent census units. To achieve this, this research proposes a cadastral and address-based population weighting technique, the Household Space Weighting (HSW) technique to measure population access. The HSW technique uses the OS AddressBase Premium data and the UKBuildings data as its ancillary data to spatially disaggregate census data from the Output Area level to the household level so as to estimate population inside Service Areas and measure potential access in a more accurate way. The application of the HSW technique will be illustrated in detail in the first data analysis chapter (Chapter Six).

3.3 The Measurement of Potential Access to Healthcare Services in the UK and Beyond

In health and healthcare related literature, regional availability and regional accessibility approaches are two traditional approaches used originally to identify physician shortage areas and then extended to measure potential access to healthcare services. Due to the limitations of both approaches, neither approach could provide an appropriate measure of potential access to healthcare services if they were applied alone (Khan, 1992). Thus, integrated availability and accessibility approaches have been proposed and developed to measure potential access in the past over two decades. This section will focus on the evolvement of the approaches to measuring potential access to healthcare services in the UK and beyond.

3.3.1 Regional Availability Approach

There are various potential access measures that have been proposed and critiqued in the existing studies, among which regional availability and regional accessibility approaches are the two traditionally most basic approaches (Love and Lindquist, 1995). The regional availability approach essentially concerns the ratio of supply to demand for a certain geographical unit, which defines as the number of opportunities available to population; while regional accessibility approach attempts to incorporate certain elements of spatial interactions between supply and demand points, which works better at low levels of spatial aggregation (Martin *et al*., 2002).

In general, the regional availability approach is simpler than the regional accessibility approach, where availability is considered as a critical variable of potential access; it is commonly presented in the form of the number or size of healthcare providers (e.g. physicians or facilities) in relation to the potential user population in a defined area (Khan, 1992). The regional availability approach involves the evaluation of the regional distribution of supply versus demand (Joseph and Phillip, 1984).

The simplest and traditionally used indicator for regional availability approach is the physician-to-population ratio (Khan, 1992; Love and Lindquist, 1995; Wing and Reynolds, 1988), which is "defined as the ratio of the number of physicians in a specified geographic area to the population within that area" (Makuc et al., 1991:347). The assumption here is that boundaries are impermeable, that is, residents of a certain region only access to healthcare services available within that region (Joseph and Phillip, 1984). This assumption may be tenable in cases where healthcare insurance only valid in a certain region, which could make it difficult for residents in the region to seek regular healthcare services in their neighboring regions (Joseph and Phillip, 1984). However, in the case of no healthcare insurance for general public (e.g. in the context of the UK), residents may travel outside their places of residence for healthcare services, particularly for specialized healthcare services (Wing and Reynolds, 1988). Thus, ignoring the migration of residents to other geographic or administrative units other than the places of residence may cause the 'boundary issue' mentioned earlier in this chapter, particularly when coarse-scale geographic or administrative units such as counties or census tracts are under investigation. Therefore, the use of the Service Area instead of the geographic or administrative unit (such as counties) could make more accurate measurement of physician availability and then access to healthcare services by using the indicator of physician-to-population ratio (Makuc et al., 1991).

Other limitations of the regional availability approach are associated with specific problems with the physician-to-population ratio itself (Lee, 1978). First, simply counting the number of physicians as the numerator may ignore the difference in productivity among physicians due to differences in work hours or time spent in clinical activities. Second, the use of the total population as the denominator does not take into account different characteristics of the population such as various levels of healthcare needs and demands.

To overcome the limitations, suggestions have been made on what indicators should be used in the measurement of the provider-to-population ratio. One suggestion is to use the Full Time Equivalent (FTE) physicians as the numerator and population-at-risk as the denominator to calculate the ratio (Khan, 1992); indicators such as income, employment, education and housing could be used instead of the total population to reflect needs (Nicholls, 2001). Concerning the 'boundary issue', the coarse scale aggregation measure ignores spatial variations among smaller subareas within the unit of aggregation, leading to overestimation or underestimation of the availability of services in its subareas (Khan, 1992). It is important that the unit of analysis is a catchment area (or Service Area) of a healthcare service rather than a geographical or administrative unit (Makuc et al., 1991).

Despite further research on the improvements of the traditional FCA methods, they are still regional availability approach because they still use administrative boundaries (such as counties) as spatial units to calculate physician-to-population ratio, without integrating space (or distance) as a discriminating variable in determining the relative availability of services; thus, strictly speaking, these measures may not reflect potential access (Khan, 1992; Luo, 2004).

3.3.2 Regional Accessibility Approach

Regional accessibility approach intends to overcome the above-mentioned limitations by acknowledging and accommodating the potential for complex interaction between supply and demand within regions (Luo and Wang, 2003). Measures using regional accessibility approach are usually based on gravity model (Joseph and Phillips, 1984). Compared to regional availability approach illustrated above, the conventional gravity model could provide a more appropriate basis for measuring potential access as it takes into account space (or distance) and distance-decay (Khan, 1992). For instance, Knox's (1978) research measured potential access to primary medical care (i.e. family doctors' surgeries) in four major Scottish cities applying a modified interaction model adapted from the Gravity Model. The results of the measurement were used for the discussion on public policies concerned with medical deprivation and area deprivation. Knox's (1979) study further illustrated the application of the modified interaction model to measure potential access to primary medical care in Aberdeen, taking more variables into account such as car ownership and population densities.

However, there are several main problems with the traditional gravity model-based accessibility measure. First, it is still a measure to assess 'place access' (e.g. measuring

potential access for certain geographical or administrative units) rather than 'population access' (e.g. measuring potential access for population and its subgroups or social groups). Second, it does not take into proper consideration the availability of physicians (such as the number and/or work hours of physicians) and does not overcome the 'boundary issue' (i.e. the mobility of residents between different subareas within a geographic or administrative unit) (Khan, 1992). More detailed illustration of the gravity model as one of the generic measures to measure accessibility to services can be referred to the review of accessibility measures in the previous Literature Review Chapter.

Due to the limitations and problems of the regional availability and accessibility approaches, neither approach could provide an appropriate measurement of potential access to healthcare services if they were applied alone. Thus, an integrated approach is needed to measure potential access in a more appropriate and comprehensive way.

3.3.3 Integrated Regional Availability and Accessibility Approach

An integrated approach was developed by Khan (1992) combining the regional availability and regional accessibility approaches to measure potential access to healthcare services drawing upon previous studies, particularly the approaches developed by Knox (1978) and Joseph and Bantock (1982) with an attempt to overcome the above-mentioned limitations. The index that Khan (1992) developed is derived as a series of individual measures, beginning with the original gravity formulation and progressing through successive stages in accordance with the definition and conceptualization of potential access. To overcome the above-mentioned limitations, the research uses the number of Full Time Equivalent (FTE) physicians instead of the number of physicians as an indicator to measure availability and the number of population-at-risk instead of the total population as an indicator to reflect needs, and takes into consideration, to some extent, the migration of potential users between subareas.

The integrated regional availability and accessibility approach provides a substantial improvement in examining physician shortage areas and measuring potential access to healthcare services. However, the original Gravity Model and the derived individual measures create difficulties for interpreting the results. To make it easier to interpret Gravity Model-based method, Luo and Wang (2003) introduced the 2SFCA method to healthcare research field based on Radke and Mu's (2000) research on spatial decomposition. The calculation process of the 2SFCA method can be referred to subsection 3.2.5 in this chapter.

The 2SFCA method is applied to measure potential access as the ratio between supply and demand that is determined within their respective travel-time catchment areas (Langford and Higgs, 2006). Various attempts have been made to apply the 2SFCA method to measure potential access to healthcare services so as to identify physician shortage designation areas since 2003. For instance, Luo (2004) applied the method to examine the primary healthcare physician shortage conditions in nine counties surrounding DeKalb in northern Illinois, US. Langford et al.'s (2007) study uses the method to examine potential impacts of alternative population distribution models on potential access to services including GP surgeries, dentists, primary schools, pharmacies and post offices in Cardiff Unitary Authority in South Wales, UK. Wang and Luo (2005) further illustrated the application of the 2SFCA method by integrating both spatial and aspatial factors to measure access to primary healthcare services in the State of Illinois, US.

There are other efforts to further improve the 2SFCA method. For instance, Luo and Qi's research (2009) proposed an enhanced method (the E2SFCA method) for measuring potential access by assigning weights to different travel time zones taking into consideration distance decay to overcome the problem of uniform access within one catchment area. Wan et al., (2012) proposed a modified E2SFCA method, which adds one more step to the enhanced method (called the 3-step Floating Catchment Area (3SFCA) method). The 3SFCA method integrates the concept of potential competition between/among services when more than one service located within a catchment area of a demand point. Langford *et al*. (2016) incorporated both public and private transport modes using dedicated network datasets to yield separate accessibility scores to better reflect the differential accessibility levels using GP surgeries in three Unitary Authorities located in South Wales, UK as a case study.

However, although the application of the 2SFCA method and its enhanced versions have improved the FCA method to an integrated availability and accessibility approach, there are still several limitations that may need to overcome. First, centroids are still used to represent subareas such as census tracts, thus causing aggregation errors. Second, although the use of dasymetric mapping as population distribution modelling provides a finer-grained population distribution data by partially disaggregating census data in the first step (see 3.2.5 for more details), there is still room for further improvement as the technique does not take into consideration characteristics of residential buildings such as

occupancy or non-occupancy (Langford *et al.*, 2007). Third, 2SFCA method and its enhanced versions are relative measurements (ratios) rather than an absolute measurement of potential access, the result from which are not appropriate to be used to assess spatial equity.

Thus, this research proposes an improved integrated approach, the Household Space Weighting (HSW) method to measure potential access and assess spatial access in a more accurate way. The HSW is a population access method to calculating the percentage of potential access for social groups at the household level by disaggregating the lowest-level census data available applying the HSW technique. The HSW method will be illustrated and demonstrated later in the first data analysis chapter - Chapter Six.

3.4 Major Factors Influence Potential Accessibility to Healthcare Services

There is a variety of factors that could have impacts on potential accessibility to healthcare services. Stanley and Farrington (1981) in Higgs and White (2000:16-17) identify the following three sets of factors that may significantly influence accessibility to services in general: "the socio-economic circumstances of the population, the location and nature of facilities to which people need access and the availability and characteristics of transport opportunities". The following is the review of major factors that may influence potential accessibility to healthcare services.

3.4.1 The Socio-economic Factor

Higher GP consultation rates are related to greater deprivation and with social groups of lower socio-economic status (Goddard and Smith, 2001). Thus, the socio-economic factors including employment, income, education, disability and housing, etc. that are reflected in the concept of deprivation in relation to *need* can be adopted as the first factor that influence potential accessibility.

Deprivation has various definitions, among others, the most commonly used definition comes from Townsend (1987:125), suggesting that deprivation "may be defined as a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs". Deprivation can also refer to "a lack, or absence, of particular attributes that contribute to some degree of suffering or relative disadvantage"; thus, it is related to people in need, the disadvantaged and the underprivileged (Higgs and White, 2000:7).

Hart (1971) coins the phrase 'the inverse care law' based on the observation of healthcare service provision in the UK, which describes situations where deprived areas are more likely to have greater healthcare needs but less likely to have access to healthcare services (Figueroa et al., 2002; Hyndman and Holman, 2001; Talen, 2003). Inequalities in healthcare services in relation to socio-economic status are well documented and the 'inverse care law' has received much empirical support particularly in terms of screening, preventive care in GP and uptake of specialist services (Goddard and Smith, 1998). Besides, deprived social groups experience more numerous and complex health problems than non-deprived social groups in general; consultation rates are significantly higher for deprived social groups when compared to non-deprived social groups (Figueroa et al., 2002; Goddard and Smith, 1998).

There are different sets of indices to measure deprivation in the UK, such as the English Index of Multiple Deprivation (e.g. the latest version is the IMD 2015), the Scottish Index of Multiple Deprivation (e.g. the latest version is the SIMD 2012) and deprivation dataset of census data (e.g. the latest version is 2011 Census Data). There are differences between the three indices of deprivation. IMD 2015 (DCLG, 2015) and SIMD 2012 (The Scottish Government, 2012) have access related sub-domain/domain, that is Geographical Barriers sub-domain of the Barriers to Housing and Services domain and the Geographic Access domain respectively. According to the conceptual framework of IMD and SMID, concerning access to services, both IMD and SMID measure relative deprivation in relation to accessibility without quantifying deprivation and accessibility, and measure deprived areas rather than non-deprived areas at the LSOA or above levels by using aggregation techniques.

In comparison, the 2011 Census Data deprivation dataset (ONS, 2011) contains four indicators that are used to classify households as deprived or non-deprived based on four selected characteristics of households, i.e. Employment, Education, Health and Disability, and Housing according to the specification given by the UK Data Service Census Support on Deprivation (England, Scotland and Wales)[7]. "A household is deprived in a dimension if they meet one or more of the following conditions:

- Employment: Where any member of a household, who is not a full-time student, is either unemployed or long-term sick.

[7] http://infuse2011.ukdataservice.ac.uk/InFuseWiz.aspx?cookie=openaccess

- Education: No person in the household has at least Level 2 education (see highest level of qualification), and no person aged 16 to 18 is a full-time student.
- Health and disability: Any person in the household has general health that is 'bad' or 'very bad' or has a long-term health problem.
- Housing: The household's accommodation is either overcrowded, with an occupancy rating -1 or less, or is in a shared dwelling, or has no central heating." (UK Data Service Census Support, 2016)

The four characteristics of households, Employment, Education, Health and Disability, and Housing of the 2011 Census Data deprivation dataset, to some extent, represents households' socio-economic factors that influence potential accessibility. The dataset measure both deprived and non-deprived households, with availability of the Output Area level data. Thus, this research will use deprivation of the 2011 Census Data as a variable to measure potential access for the social groups, the Deprived and Non-Deprived Households, and assess spatial equity based on the *equality* and *need* conceptions of the conceptual framework of spatial equity adopted in this research.

3.4.2 The Demographic Factor

The demographic factor such as age may influence potential accessibility to healthcare services. For instance, different age groups may have access to healthcare services at different levels or frequency (Rogers, *et al*., 1999; Scaife et al., 2000). This is reflected in either expenditures such as Kovar's (1986) research or consultation rates such as in Rogers, *et al*.'s (1999) research, with patterns of utilization of healthcare services frequently being considered as its manifestation (Parker and Campbell, 1998; Phillips, 1979).

In general, there are people of two age groups who are disproportionately large users of healthcare services – the elderly and young children (Kovar, 1986; Rogers, *et al*., 1999). As the percentage of the aged who are 65-69 is decreasing while the percentage of those who aged 75 and over is increasing, the access of people of the latter age groups to healthcare services will be a major policy issue of concern that deserve attention in the future (Love and Lindquist, 1995; Rice and Feldman, 1983). For young children, the average consultation rate for children aged 0-4 is seven per year, while the figure is only three for children aged 5-15 (Rogers, *et al*., 1999); parents with young children aged 0-4 are more likely to be frequent healthcare service attenders compared to parents with

young children over 5 years old (Scaife et al., 2000). Thus, people of the two age groups, the young children under 5 and the elderly aged 75 and over are large users of healthcare services.

Given the heavy demands of people of these two age groups for healthcare services (Love and Lindquist, 1995; Rogers, *et al*., 1999), measuring the potential access of people of these two age groups to healthcare services based on demands could be important in order to assess the adequacy and equitable access of healthcare services. Thus, it is necessary to consider larger demands of particular social groups classified by age in addition to greater needs of specific social groups classified by deprivation. Therefore, the *demand* conception will be included into the conceptual framework of spatial equity in this research.

As this research focuses on socio-spatial dimensions rather than economic dimension, consultation rates rather than expenditures will be used as an indicator to measure demands by distinguishing heavy and light user groups. To be more specific, the Heavy User Group is the most frequent user group of healthcare services, here referring to residents classified by age who have the highest GP consultation rates (i.e. young children aged 0-4 and the elderly aged 75 and over); while the Light User Group is the least frequent user group of healthcare services, here referring to residents classified by age who have the lowest GP consultation rates (i.e. the rest aged 5-74) (Rogers, *et al*., 1999).

3.4.3 Physical Distance

Physical distance to healthcare services have long been recognized as an important factor influencing accessibility to services (Gregory et al., 2000). The existing research has indicated that increasing distance from healthcare services is associated with lower level of access to those services in areas such as the uptake of screening and immunization (Goddard and Smith, 1998) and primary healthcare services (Nemet and Bailey, 2000). This has resulted in that the net benefits of healthcare services such as GP surgeries are generally higher for those living closer because of more opportunities and less travel costs when compared with those living further away (Knox, 1978).

There has been convincing evidence showing that distance has marked negative impacts on consultation rates (such as Hopkins et al, 1968). The physical distance from services is a deterrent to the use of the services in general, but there are variations depending on the nature of the services and different socio-economic and demographic groups who access the services (Figueroa et al., 2002; Gregory et al., 2000). For instance, distance from

home to GP practices is a key factor in access to GPs from patients' point of view, but residents do not always choose their nearest GPs (Knox, 1978).

However, for most residents, proximity to GP practices is very important; distance is very crucial indeed for certain social groups such as the elderly and mothers with young children (Knox, 1978). Besides, residents could be more willing to travel longer distances to access specialized services than routine healthcare services (Smith *et al*. (1985) in Love and Lindquist (1995). Thus, it is necessary to specify what type of healthcare services are under investigation (e.g. primary, secondary or tertiary healthcare services), and identify the maximum distances that different social groups may be willing to travel and by what travel modes (e.g. car, public transport, walking or cycling) while measuring potential access (Love and Lindquist, 1995).

Concerning the socio-economic and demographic factors and their related two categories of social groups mentioned above, more deprived households may less likely to own a car (Goddard and Smith, 2001), and it could be inconvenient for the Heavy User Group (residents aged under 5 and over 74) to travel by public transport (Hillman *et al*., 1973). Based on examining the mobility of different social groups, including school children, working adults, mothers with young children, the elderly and people with disabilities, Hillman *et al*. (1973) discover that half a mile is often considered as the ceiling for elderly walkers and mothers with preschool children. Thus, it is considered as reasonable walking distance (roughly ten-minute walk) for the Heavy User Group and the Deprived Household (who are less likely to own a car). Therefore, this research will use half a mile walking distance as the maximum distance threshold to measure potential access to healthcare services, more specifically primary healthcare services for social groups classified by deprivation and age in relation to consultation rates.

3.4.4 Urban Form (Urbanity/Rurality)

Urban form can be a fourth factor that influence the level of accessibility as one fundamental advantage of an urban settlement is about 'access' (Lynch, 1984). In general, the level of potential access could be lower in rural areas compared to urban areas within a city. Because the lower density and higher dispersion of most rural residents associated with a sparse road network (particularly with less frequent public transport services) could result in greater average separation between residents and healthcare services in rural areas even if supply thresholds are similar (Joseph and Bantock, 1982; Love and Lindquist, 1995; Martin *et al*., 2002).

The existing research concerning accessibility to healthcare services in rural areas has been shifted from focusing on the association between accessibility and deprivation that is related to higher levels of need (e.g. Haynes and Gale, 1999; 2000) to including the association between accessibility and other factors such as distance controlling for needs (e.g. Haynes et al., 1999). Besides, the existing research has stressed the significance of public transport in rural areas in determining the nature and extent of deprivation (Moseley, 1979; Nutley, 1985). However, even in those rural areas where the provision of services is high, many non-car-owning rural residents may still have low levels of accessibility due to the lack of good quality public transport or public transport services at particular hours of the day (Higgs and White, 2000).

Thus, problems concerning accessibility to healthcare services in rural areas could be a combination of the decreased levels of healthcare service provision largely due to the consideration of intensification and rationalization of public services that was taken place in the 1970s-1980s and sparse provision of public transport (Higgs and White, 2000). From this point of view, those rural residents who are "on the receiving end of cutbacks in both healthcare services and public transport can be hypothesized as being 'doubly-disadvantaged'" (Higgs and White, 2000:12). To overcome some of accessibility problems that are resulted from the intensification and rationalization of public services, measures such as more accessible near-patient testing centers, community outreach clinics and satellite treatment units have been introduced (Figueroa et al., 2002). For 'doubly-disadvantaged' rural residents, it could be necessary to measure accessibility using the same walking distance as urban residents (for example the maximum walking threshed of half a mile) to assess the potential accessibility gap between rural and urban residents and then evaluate the implication of the above-mentioned measures that have been implemented.

Inequitable access of rural residents to healthcare services has long been admitted and policy recommendations have been proposed to tackle this issue. The cause of 'doubly-disadvantaged' issue could be more related to economic dimension rather than socio-spatial dimension. Moreover, this research focuses on pedestrian-oriented access measurement (using half a mile as the maximum walking distance) and considers the concentration of public services in urban areas or areas with higher population density rather than in rural areas or sparsely populated areas as an economic factor rather than socio-spatial factor (see Chapter Two for more details). Thus, it will not adopt urban form

(urbanity/rurality) as a key factor to illustrate potential accessibility and potential access measurement. However, related aspects, such as the association between mobility and access by urbanity/rurality, factors related to mobility, and the implication of the establishment of satellite surgeries will be touched upon later in Further Research.

3.5 Summary

Reviewing planning literature reveals that although a number of studies have integrated concepts related to equity into planning process and connect it with the measurement of potential accessibility to services, there is a lack of a comprehensive spatial equity assessment framework that integrates the size (representing availability) and quality of services. Reviewing health and healthcare-related literature reveals that although the existing studies have developed integrated regional availability and accessibility approaches, they are relative potential access measurements for identifying physician shortage areas on the regional scale rather than an absolute measurement for measuring potential access to and assessing spatial equity of healthcare services on the city scale.

To be more specific, methodologically, the existing methods for potential accessibility measurement are still assessing place access rather than population access as they use centroids to represent census units rather than measuring access for population and its subgroups. Technically, although the disaggregation techniques used in the existing studies have improved the accuracy of population estimation inside Service Areas and potential access measurement, there is still room for further improvement. Because the existing studies are unable to distinguish residential buildings from non-residential buildings and unable to classify residential buildings by dwelling type in use so as to make population estimation inside Service Areas and calculate potential access in a more accurate way.

However, with the updating of more accurate cadastral and address-based data, such as the UKBuildings data and the OS AddressBase Premium data in the UK context, there could be an alternative technique to further improving the accuracy in population estimation, and further reducing aggregation errors by replacing the use of centroids (both geographic and Population Weighted Centroids) to represent census units when measuring potential access. To achieve this, this research proposes a cadastral and address-based population weighting technique, the Household Space Weighting (HSW) technique using the UKBuildings data and the OS AddressBase Premium data as its ancillary data to disaggregate census data from the Output Area level to the household

level so as to estimate population inside Service Areas and measure population access in a more accurate way.

Based on the literature review in the previous chapter and this chapter, two main research gaps have been identified. First, despite improvement, the existing spatial disaggregation techniques are still not accurate enough in making population estimation inside services areas and measuring potential access. Second, there is a lack of a comprehensive GIS-based Spatial Equity Assessment Framework for guiding the measurement of potential accessibility integrating size (i.e. potential access) and the assessment of spatial equity integrating quality for social groups at the household level on the city scale.

In order to fill these research gaps, this research will emphasize the following two aspects. First, propose an improved disaggregation technique to make population estimation inside Services Areas and measure potential access in a more accurate way. Second, develop a more comprehensive GIS-based Spatial Equity Assessment Framework for guiding potential accessibility and potential access measurement and spatial equity assessment. Detailed illustrations and demonstrations of the improved disaggregation technique and the assessment framework will be provided later in the two data analysis chapters (Chapter Six and Seven) after the Introduction to Case Study and Methodology chapters.

Chapter Four: Introduction to Case Study

4.1 Overview

This chapter will emphasize introducing the background on health service and healthcare delivery system in the UK, and the case study city and GP practices in the city. The purpose of the chapter is to provide basis for the following Methodology Chapter.

There are mainly two sections in this chapter. The first section will focus on the healthcare system in the UK, which includes the National Health Service (NHS), original and current core objectives and principles of the NHS, the healthcare delivery system and its quality assurance mechanism. The second section will focus on the case study city of Newcastle and GP practices in the city, which contains a city profile, main reasons for choosing Newcastle and the location, size and quality of GP practices in the city.

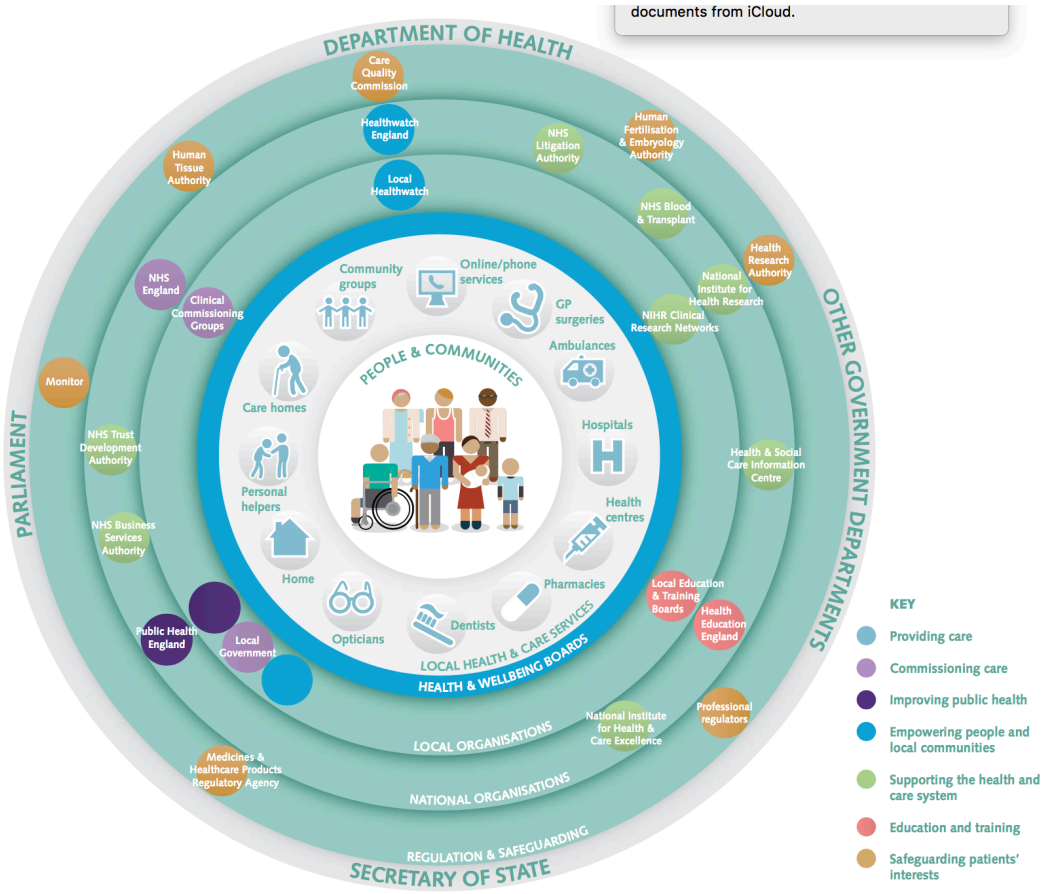
4.2 Healthcare System in the UK

4.2.1 National Health Service (NHS)

The UK healthcare system, the NHS was established in 1948 in the aftermath of the Second World War (Grosios et al., 2010; NHS, 2013). The NHS overall comprises of two broad sections - dealing with strategy, policy and management as well as coping actual medical care that is further divided into primary care, secondary care and tertiary care (Grosios et al., 2010). Figure 3 demonstrates the healthcare system in England from April 2013.

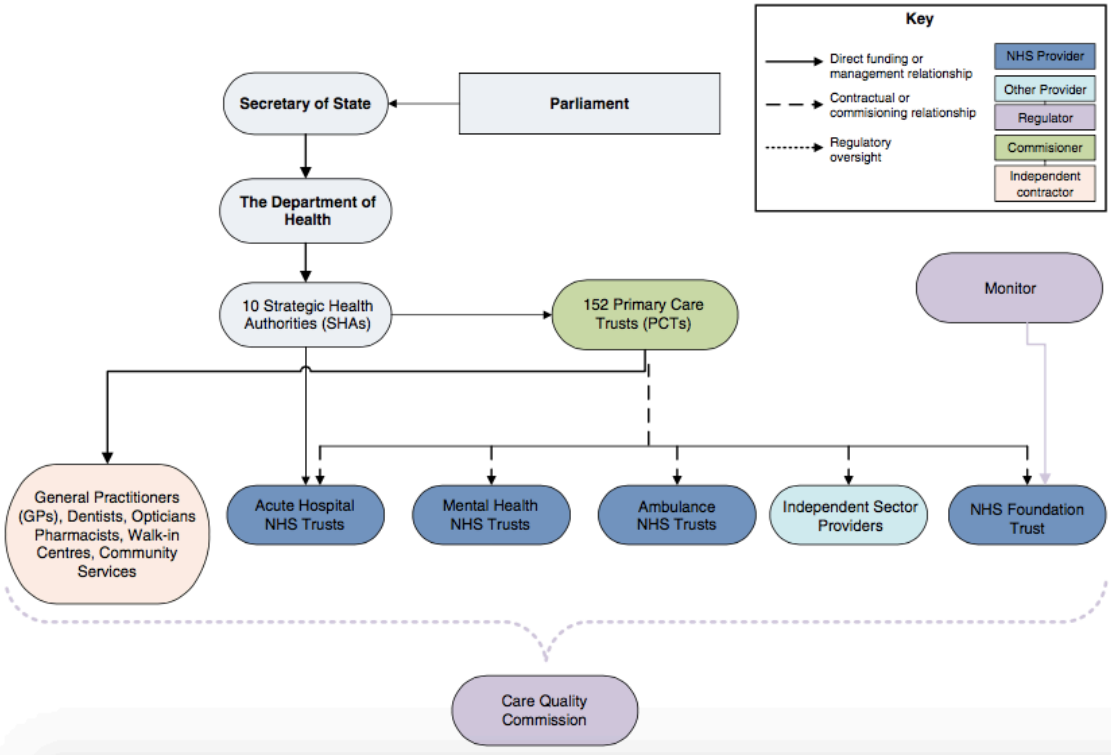
The NHS operates differently in England, Scotland, Wales and Northern Ireland, with each country having its own distinct structure and organization; the Central Government is responsible for health care and health policy in England, while it is the responsibility of the respective devolved governments of the rest three countries (Grosios et al., 2010). Emphasis will be placed on NHS England as the case study of this research is in England. Figure 4 provides an overall organizational structure of the NHS England in 2010.

Figure 3 The Healthcare System in England from April 2013



Source: NHS (2013:3)

Figure 4 The Overall Organizational Structure of the NHS England in 2010



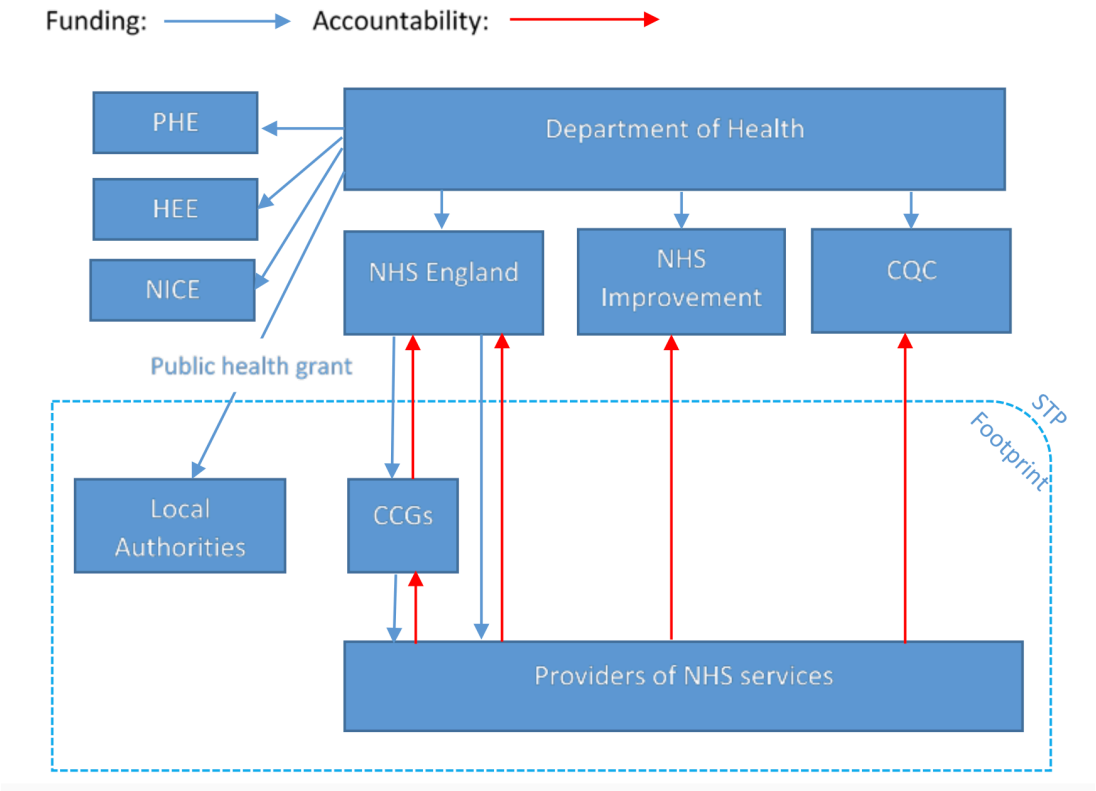
Source: Grosios et al. (2010:533)

As can be seen from Figure 4 that the Department of Health is in charge of healthcare in England. There were 10 Strategic Health Authorities (SHAs) and 152 Primary Care Trusts (PCTs) in 2010. The SHAs manage the NHS at the local level, and the PCTs manage, commission services, and ensure the availability of public healthcare services and provision of community healthcare services. The main types of Trusts include Acute Hospital NHS Trusts, Mental Health NHS Trusts, Ambulance NHS Trusts, Independent Sector Providers and the NHS Foundation Trust. The Care Quality Commission[8] (CQC) provides overall monitoring over healthcare services in England, with an exception that the NHS Foundation Trust is regulated by a separate independent Monitor.

The healthcare system in the UK has evolved in the past decades. The constant changes in the NHS's configuration of structures and services have led to a shift from central to local decision making, with health authorities being merged or devolved functions to primary care trusts, and hospital trusts rationalizing services to fewer sites and community trusts combining their services with primary care organizations (Figueroa et al., 2002). For instance, the SHAs and PCTs were abolished so as to transfer greater autonomy and accountability to local authorities in 2013 when GP Consortia supported by the NHS Commissioning Board were expected to take responsibility for commissioning healthcare services instead (Department of Health, 2013). Major reforms were introduced in *the Health and Social Care Act 2012* to the structure of the health service in England, with many provisions coming into force on 1 April 2013 under the Act (Powell, 2017). Figure 5 shows a simplified diagram of the post-reform structure of the NHS in England in 2017.

[8] http://www.cqc.org.uk/

Figure 5 The Structure of the NHS in England (as at June 2017)



Source: Powell (2017:3)

In order to further explain the healthcare system in the UK, the NHS's original and current core objectives, principles, the delivery system and quality management mechanism will be illustrated in the following subsection.

4.2.2 Original and Current Core Objectives and Principles

The core objectives of the NHS were that it should be available to all, comprehensive in healthcare services provision and free at the point of use at its establishment in 1948 (Delamothe, 2008; Oliver, 2005; Webster, 2002). The availability to all here or universal coverage means that all 'ordinary residents' in the UK are entitled to healthcare that is largely free at the point of use (Boyle, 2008). Although the NHS has going through numerous political and organizational changes, it is still funded largely by taxes and national insurance contributions, which remains a service that is universally available, caring for people based on need rather than ability to pay (Grosios et al., 2010).

The NHS provides comprehensive services, including preventative services; inpatient and outpatient (ambulatory) hospital (specialist) care; physician (general practitioner) services; inpatient and outpatient drugs; dental care; mental health care; learning disabilities and rehabilitation (Boyle, 2008). Although the above-mentioned healthcare services are no longer entirely free at the point of use for all health services (particularly

for those services relating to pharmaceuticals, dentistry and optical services), most healthcare services remain free; even though certain user charges may occur, there are extensive exemptions (Oliver, 2005). The NHS now operates under the principle that "good healthcare should be available to all, with access based on clinical need, not ability to pay" (NHS, 2013).

4.2.3 Healthcare Delivery System

There are three-tier healthcare services in the UK, the primary care, secondary care and tertiary care as mentioned above, and most healthcare services are delivered by the NHS with the above-mentioned principles (Goddard and Smith, 2001). The primary care mainly includes community care, General Practitioners (GPs), Dentists, Opticians and Pharmacists (for medicines and medical advice) (Grosios et al., 2010; NHS, 2013). All residents are registered with GPs who are responsible for delivering primary care (Goddard and Smith, 2001).

The secondary care includes hospital-based care accessed through GP referral, which is delivered by a set of NHS providers (Grosios et al., 2010; NHS, 2013). The tertiary care includes specialist hospitals (Grosios et al., 2010; NHS, 2013). Besides public resources, there is a small private sector that is focusing on the provision of routine elective procedures (mostly delivered by NHS clinicians) to people who are insured and who choose to pay related fees (Goddard and Smith, 2001).

GPs are usually the first point of contact for physical and mental health concerns and conditions, who act as gatekeepers for access to secondary healthcare services (Boyle, 2008; NHS, 2013). Generally speaking, patients cannot gain access to the secondary care unless referred by a GP except for emergencies (Goddard and Smith, 2001). There were over 36,000 GPs working in over 8,300 practices in England in 2013[9]; all GP practices are required to be a member of a Clinical Commissioning Group (CCG) who provides organizational infrastructure that enables GPs to commission services for their local communities working with other health professionals (NHS, 2013). Hospitals (directly responsible to the Department of Health) together with Foundation Trusts (established as semi-autonomous and self-governing public trusts) provide healthcare services to residents (Boyle, 2008).

[9] GP Practice Data 2010. Available at: www.indicators.ic.nhs.uk.

4.2.4 Quality Assurance Mechanism

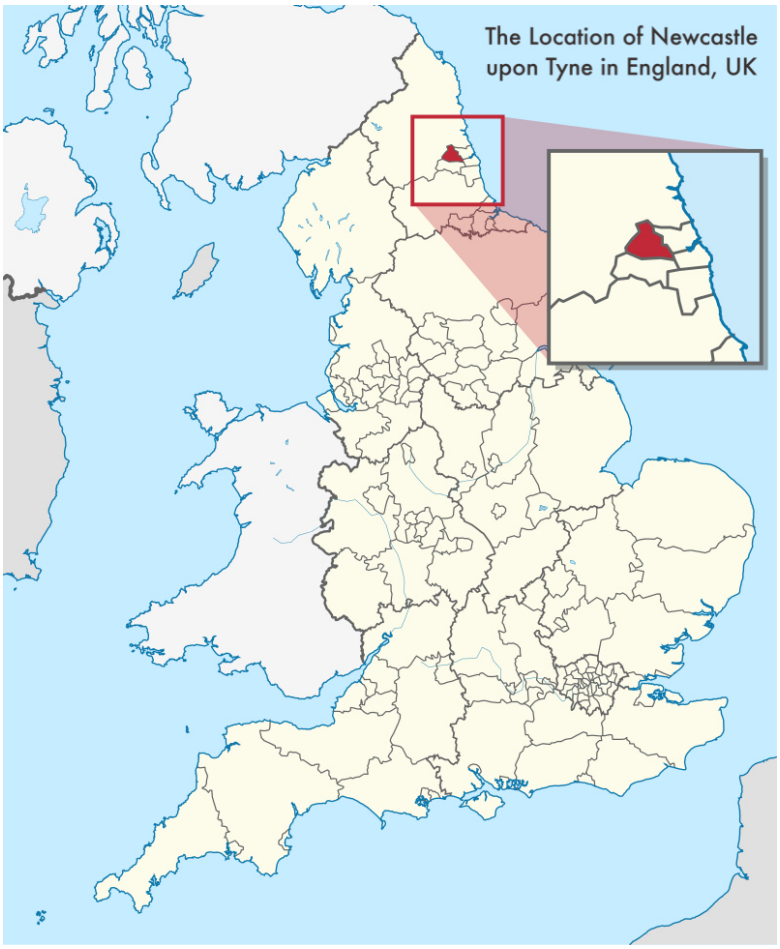
For regulating services, the National Institute for Health and Clinical Excellence (NICE) is responsible for developing national guidelines and standards related to healthcare services (Grosios et al., 2010). CQC is responsible for assessing and making judgments concerning the level of safety and quality of health and social care services provided by providers of healthcare of all types, including NHS funded healthcare service providers (CQC Website, 2016).

For assessment, CQC takes into consideration information received from the providers themselves and other organizations, and conducts on-site inspections (CQC, 2015). Healthcare services providers must register with CQC in order to operate, which involves meeting a set of essential quality and safety standards known as registration requirements that are drawn up by CQC working with NICE, patients and local residents (NHS, 2013).

4.3 Newcastle as the Case Study City and GP Practices in the City

Newcastle is situated in the North East of England, UK. It is chosen as the city to conduct case study for the following reasons. First, the city has GP practices of different sizes (measured by the number of FTE GPs) and qualities (in accordance with the CQC ratings). Second, the city has a wide variation in deprivation and age groups in general, with higher concentrations of the Deprived Household and Heavy User Group in several areas of the city (see Map 2 and 3). This is important because population classified by deprivation and age are chosen as the spatially defined social groups to measure potential access to GP practices and assess spatial equity. Third, there is easy access to information and the site as the researcher is based in the city. Map 1 shows the location of the city in England.

Map 1 The Location of Newcastle upon Tyne in England, UK

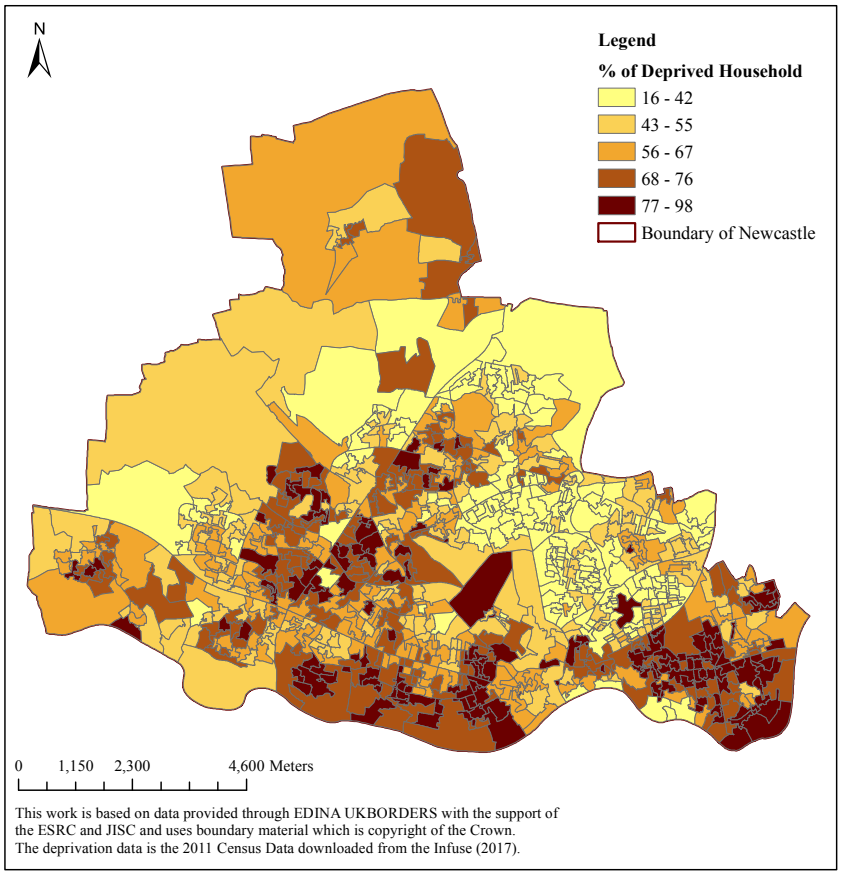


Source: https://en.wikipedia.org/wiki/Newcastle_upon_Tyne

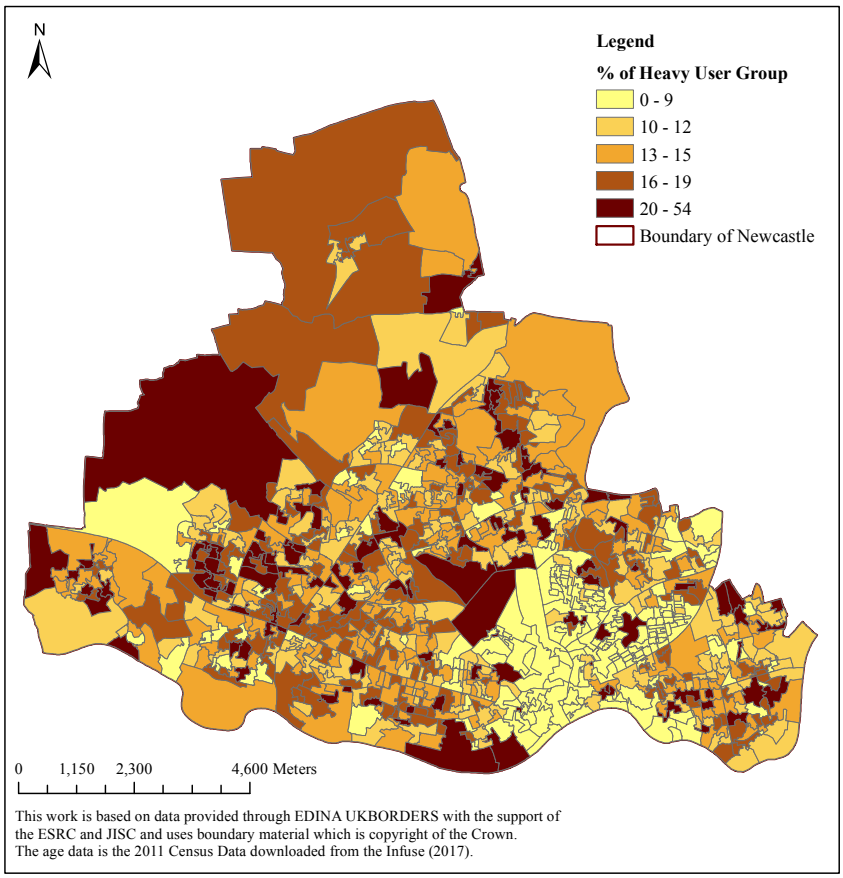
According to 2011 Census Data (ONS, 2011), the city has a population of 280,177, of which 35,910 falls into the category of the Heavy User Group; there are 117,153 households, of which 69,649 (59.45%) falls into the category of the Deprived Household. Deprivation in the city is higher than the England average, with approximately 13,600 children living in poverty; the health of residents in the city is varied compared to the England average (Public Health England, 2013). Map 2 and 3 show the distribution of the Deprived Household and Heavy User Group in the city.

There are 44 GP practices of different qualities in Newcastle, of which 3 GP practices are with 'Outstanding' CQC rating, 39 GP practices with 'Good' CQC rating, 1 GP practice with 'Inadequate' CQC rating and 1 GP practice with 'Requires Improvement' CQC rating by the time of finalizing the GP practice dataset for this research (as of September 2017). The location of the 44 GP practices by quality (CQC ratings) in the city can be referred to Map 4; the size and quality of the 44 GP practices can be referred to Table 6.

Map 2 The Percentage of the Deprived Household in Newcastle (Quantile)



Map 3 The Percentage of Heavy User Group in Newcastle (Quantile)



As can be seen from Map 2 and 3, there are mismatches between the distribution of the Deprived Household and the Heavy User Group in Newcastle. The Deprived Household is concentrated in the riverside and the south-eastern part of the city with higher population densities, while the Heavy User Group is concentrated in the north-western part of the city where with lower population densities. GP practices are concentrated in areas of the city where population densities are higher (see Map 4). These patterns may indicate, to some extent, the equitable/equal or inequitable access of the Deprived Household and the Heavy User Group to GP practices in the city on the city scale. This will be assessed and illustrated in the case study in Chapter Six.

Map 4 The Location of GP Practices by Quality in Newcastle

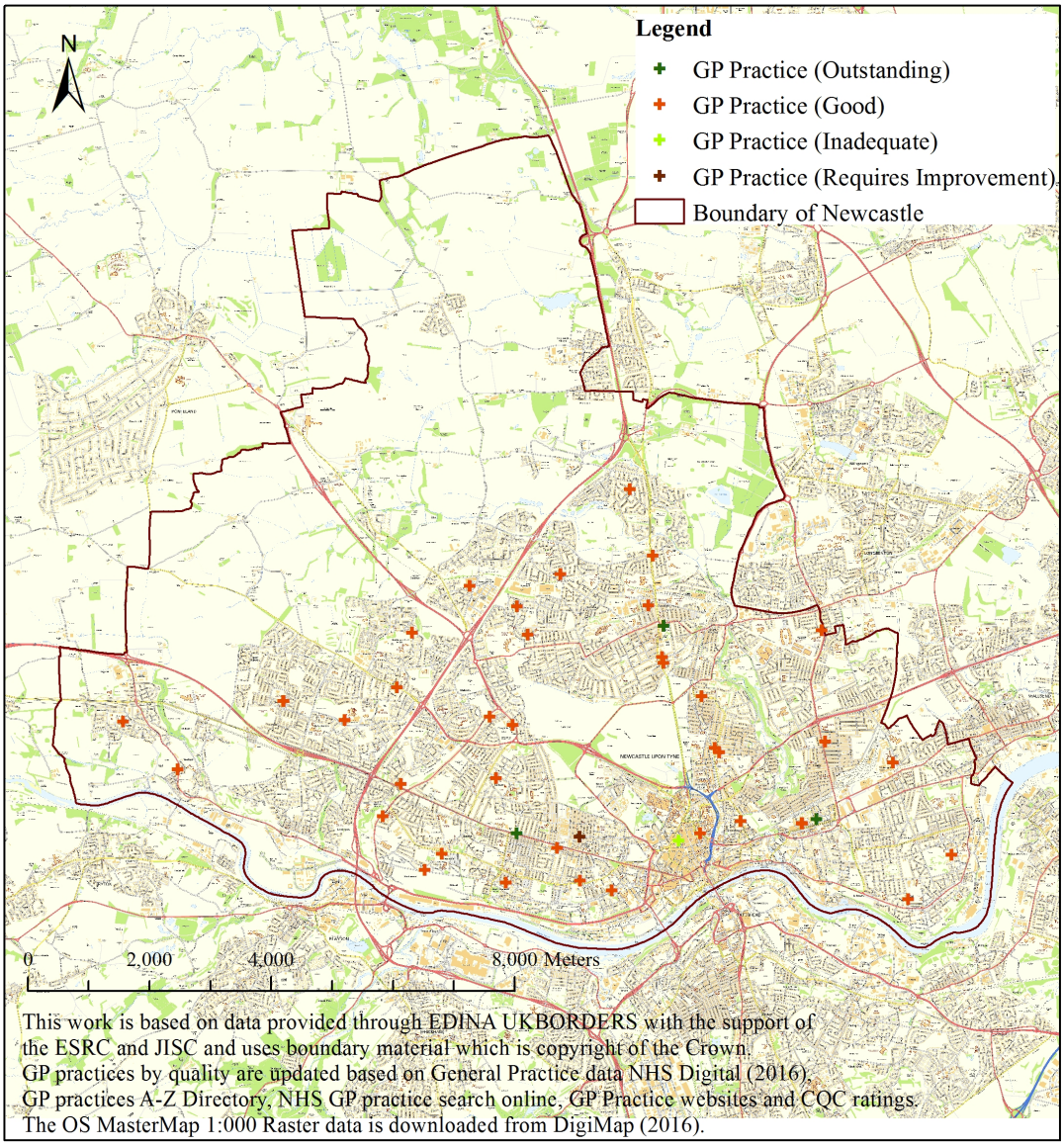


Table 6 The Size and Quality of GP Practices in Newcastle

No.	Practice Code	Name	No. of FTE GP in Newcastle	CQC Rating
1	**A86027**	Newcastle Medical Centre	2.48	Inadequate
2	**A86003**	Saville Medical Group - Saville Place Surgery	6.84	Good
3	**A86037001** (Y02726)	Grainger Medical Group -Scotswood - Branch	0.75	Good
4	**A86030**	Betts Avenue Medical Centre	1.94	Good
5	**A86025002**	Westerhope Medical Group – Denton Road - Branch	1.92	Good
6	**A86038**	Newburn Surgery	2.77	Good
7	**A86026**	Throckley Primary Health Care Centre	5.71	Good
8	**A86029001**	Thornfield Medical Group-Shiedfield Health Centre- Branch	2.65	Good
9	**A86007**	Avenue Medical Practice	1.50	Good
10	**A86015**	Holly Medical Group	4.56	Good
11	**A86020**	The Surgery - Osborne Road	5.26	Good
12	**A86028**	Regent Medical Centre	2.16	Good
13	**A86006**	Roseworth Surgery	4.4	Good
14	**A86018**	The Grove Medical Group	4.6	Good
15	**A86036**	Gosforth Memorial Health Centre	5.53	Outstanding
16	**A86008001**	The Park Medical Group - Kingston Park Avenue - Branch	3.11	Good
17	**A86008**	The Park Medical Group - Main	3.11	Good
18	**A86017001**	Hillsview Surgery-Branch	2.25	Good
19	**A86030001**	Kenton Medical Centre-Betts Avenue - Branch	1.94	Good
20	**A86035**	Broadway Medical Centre	1.6	Good
21	**A86033**	Brunton Park Health Centre	3.4	Good
22	**Y00184**	Dilston Medical Centre	2.81	Requires Improvement
23	**A86037**	Grainger Medical Group - Elswick Health Centre	0.75[10]	Good

[10] This is Grainger Medical Group with the Organization Code of A86037. After the Scotswood GP Practice (refer to GP practice 3 with previous Organization Code of Y02726) being merged into the Grainer Medical Group as branch surgery in February 2015, the number of FTE GPs at the Grainger Medical Group doubled, increasing from 0.7 to 1.50 in the 2016 General Practice data. Thus, in the absence of the data on the number of FTE GPs for branch surgery, the number of FTE GPs was equally divided between/among in

24	**A86017**	Cruddas Park Surgery	2.25[11]	Good
25	**A86004**	Prospect Medical Group	8.33	Good
26	**A86021**	Holmside Medical Group - Benwell - Main	2.3	Good
27	**A86012**	West Road Medical Centre	6.66	Outstanding
28	**A86031**	Fenham Hall Medical Group	4.17	Good
29	**A86021001**	Holmside Medical Group - Branch (Chapel House)	2.3	Good
30	**A86022**	Parkway Medical Group	6.14	Good
31	**A86025**	Westerhope Medical Group-Westerhop Village-Main	1.92	Good
32	**A86013**	Denton Park Medical Group	4.01	Good
33	**A86601**	Denton Turret Medical Centre	4.6	Good
34	**Y02711**	Ponteland Road Health Centre - Freeman Clinics Ltd.	0.55	Good
35	**A86025001**	Westerhope Medical Group - Blakelaw Clinic-Branch	1.92	Good
36	**A86003001**	Saville Medical Group (Newbigg in Hall)- Branch	6.84	Good
37	**A86024**	Heaton Road Surgery	4.16	Outstanding
38	**A86023001**	Benfield Park Medical Group-Molineux Street Centre- Branch	1.76	Good
39	**A86029**	Thornfield Medical Group - Main	2.65	Good
40	**A86040**	St Anthony's Health Centre	6.82	Good
41	**A86011**	Walker Medical Group	8.05	Good
42	**A86023**	Benfield Park Medical Group - Main	1.76	Good
43	**A86010**	Biddlestone Health Group	4.78	Good
44	**A86041**	Swarland Avenue Surgery	2.67	Good

Source: Updated based on General Practice data (including *the number of FTE GPs per GP practice* as at September 2016) NHS Digital (2016), GP Practices A-Z Directory, NHS GP practice search online data and GP practice websites (including the GP practice quality data of CQC rating as at September 2017).

the main practice and the branch surgery to avoid 'double counting'. This applies to other instances where the same service providers have both main and branch surgeries.

[11] This is Cruddas Park Surgery with the Organization Code of A86017 that has a branch called Hillsview Surgery (refer to GP practice 18). The number of FTE GPs of the main and branch surgeries is not available, but the number of GPs (6) is available. Considering the rough positive association between the number of registered patients and the number of FTE GPs in GP practice, the mean of the other three main surgeries in Newcastle with six GPs (i.e. Holly Medical Group – A86015 is 4.56, Fenham Hall Medical Group – A86031 is 4.17 and Westerhope Medical Group – A86025 is 4.78) was calculated (4.50) and then divided equally for the Cruddas Park Surgery (main; 2.25) and Hillsview Surgery (branch; 2.25).

4.4 Summary

In this chapter, two main sections were presented, with the first one focusing on the healthcare system in the UK as a whole, including the NHS, original and current core objectives and principles of NHS, the healthcare delivery system and the quality assurance mechanism. This offers a big picture of the case study for this research. The second section emphasized the case study city of Newcastle and GP practices in the city, which contains a city profile, main reasons for choosing Newcastle to conduct the case study, and the location, size and quality of GP practices in the city. This provides the specific context of the case study for this research. Both sections provide basis for the upcoming Methodology Chapter.

Chapter Five: Methodology

5.1 Overview

Following the Introduction to Case Study in the previous chapter, this chapter focuses on methodology of the research. The purpose of this chapter is to illustrate how this research was conducted, including the whole design of the research and how related data was prepared and analyzed.

The chapter will start with data preparation and justifications for variables and data used. It will then emphasize two-phase data analysis process of the research using GP practices in the city as a case study. In the first phase, the proposed HSW technique and the PWC technique will be illustrated and compared in population estimation inside the merged Service Areas of all GP practices in Newcastle. This is to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas. And then, the two techniques will be illustrated and further compared in the context of the application of the PWC and HSW methods to measure potential accessibility and potential access taking into account the overlay of Service Areas in the city on the city scale (i.e. considering city as a platform). This is to demonstrate that the HSW method is more accurate in terms of potential accessibility and potential access measurement.

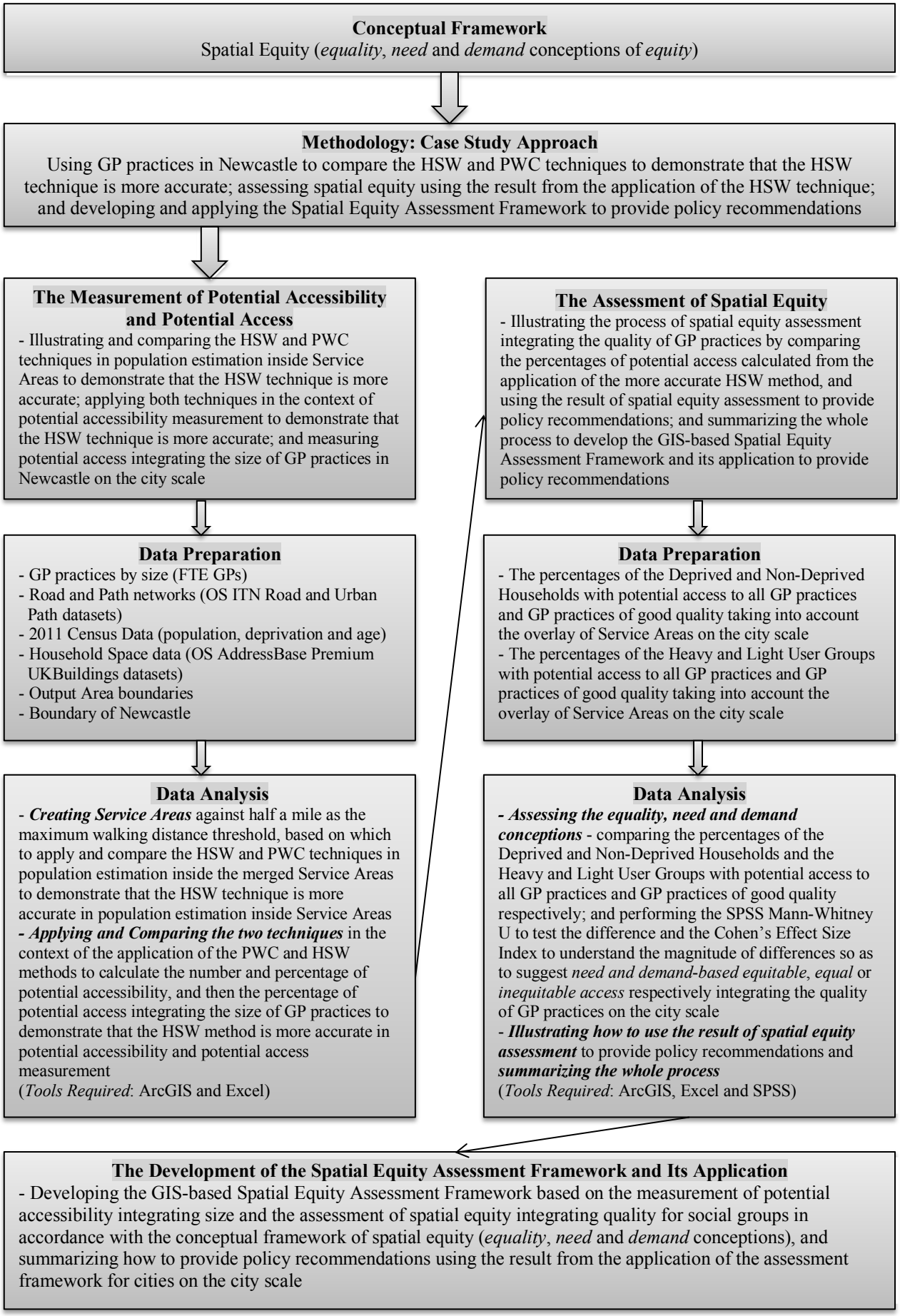
In the second phase, spatial equity assessment of GP practices will be illustrated using the result from the application of the HSW method in the city integrating quality based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). And then, how to use the result of spatial equity assessment to provide policy recommendations will be illustrated for cities on the city scale. After that, the GIS-based Spatial Equity Assessment Framework and its application to provide policy recommendations will be summarized based on the whole process of potential accessibility measurement integrating size and spatial equity assessment integrating quality for social groups at the household level on the city scale. Finally, methodological and empirical limitations of this research will be reflected, and further research will be proposed on related areas that may be worth further investigation.

5.2 Methodology

This research adopts case study approach using GP practices in Newcastle to illustrate and compare the HSW and PWC techniques in population estimation inside Service

Areas and in potential accessibility and potential access measurement and illustrate the application of spatial equity assessment using the result from the application of a more accurate potential access measurement. The GIS-based Spatial Equity Assessment Framework was developed based on the whole process of illustrations and comparisons mentioned above, and the application of the assessment framework to provide policy recommendations was also illustrated and summarized. Figure 6 indicates the design of this research. It includes the conceptual framework of spatial equity, methodology that reflects the process of data preparation and analysis, and the development and application of the assessment framework.

Figure 6 The Research Design



5.2.1 Data Preparation

In order to illustrate and compare the proposed Household Space Weighing (HSW) technique and the Population Weighing Centroid (PWC) technique in estimating population inside Service Areas, illustrate and compare the PWC and HSW methods in measuring potential accessibility and potential access, and then assess spatial equity in accordance with the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions), the following datasets and tools were required for calculations and analysis.

- ***Data Required***:

1) GP Practices by size (*FTE GPs*) and quality (*CQC ratings*)
2) 2011 Census Data (*population, deprivation and age*)
3) Household Space (*OS AddressBase Premium* and *UKBuildings* datasets)
4) 2011 Output Area population weighted centroids
5) OS ITN Road and Urban Path Networks
6) Output Area boundaries
7) The boundary of Newcastle

- ***Tools Required***: ArcGIS, Excel and SPSS

Related databases were created in the following six steps. The first step was the creation of a database for GP practices in Newcastle. This was achieved by clipping the existing General Practice data (including the number of FTE GPs per GP practice dataset) by the boundary of Newcastle; updating the clipped data against the GP Practices A-Z Directory, NHS GP practice search online data and GP practice websites to incorporate the GP practice quality data (CQC ratings); and geo-editing the location of some GP practices updated against the OS MasterMap 1:1000 raster data downloaded from the DigiMap.

It is worth noting here that walk-in centers were not counted as GP practices because unlike GP practices they require no registration and provide limited scope of healthcare services, and some of them are nurse-led rather than GP-led. All GP practices were counted without the distinction between GP surgeries and satellite units because there is no obvious distinction between them in terms of availability particularly when they are measured by the number of GPs or Full Time Equivalent (FTE) GPs. In terms of the size of GP practices concerning availability measurement, the number of FTE GPs rather than the number of GPs was used as an indicator because the FTE GP is closer to reality since it takes into consideration working hours of GPs in each GP practice.

The second step was the creation of a dataset using road and urban path networks data (OS ITN Road and Urban Path Networks). The data was downloaded from the DigiMap, and half a mile walking distance was identified as the maximum walking distance threshold. Walking was chosen as travel mode using road and urban paths networks because the Deprived Household is less likely to own a car, and some may even have difficulties in affording public transport, and there is a research gap as the majority of studies have used car and/or public transport travel as the travel mode using road networks rather than road and urban paths networks to create Service Areas when GIS-based network analysis is involved. Half a mile was identified as the maximum walking distance threshold because this is often regarded as the ceiling for elderly walkers and mothers with preschool children (Hillman *et al*., 1973). Network distance rather than straight line distance was used because the former is closer to reality as most people would use road networks and urban paths to reach services (Christie and Fone, 2003).

The third step was the creation of socio-demographic census database. The datasets of population, deprivation and age were downloaded from the InFuse[12]. The 2011 Census Data deprivation dataset (rather than other deprivation indices such as IMD and SIMD) was chosen to measure *need* because the four characteristics of households (Employment, Education, Health and Disability, and Housing) reflect socio-economic status. Unlike IMD and SIMD, the 2011 Census Data deprivation dataset can be used to measure both the Deprived Household and the Non-Deprived Household. Age was chosen as the demographic factor to measure *demand* (i.e. the age groups under 5 and over 74 represent the Heavy User Group and the rest age groups at 5-74 represent the Light User Group) because age groups can represent different levels of demand for healthcare services that are reflected in consultation rates (Rogers, *et al*., 1999).

The fourth step was the creation of the database of residential buildings. Residential buildings were selected based on the AddressBase Premium data provided by the Ordnance Survey and UKBuildings data purchased from the GeoInformation Group. Three steps were followed to select residential buildings from all buildings in Newcastle before the calculation of the number of Household Spaces of residential buildings to represent the number of households in the city. First, Import the selected residential buildings of the UKBuildings dataset for Newcastle to ArcGIS. This was achieved by importing the shapefile format of UKBuildings dataset and clipping the dataset by

[12] http://infuse.ukdataservice.ac.uk/

Newcastle Boundary to ensure the inclusion of only Newcastle data. And then, select '1' (representing 'Residential Building') and '3' (representing 'Mixed Residential and Non-Residential Building') from the header 'RNR' (Residential/Non-Residential)[13] based on the Attribute Document of the UKBuildings using 'Select by Attribute' function in the Attribute Table. Second, clean the OS AddressBase Premium datasets by selecting 'D' (representing 'a record which is linked to Royal Mail's postcode Address File') from the header 'ADDRESSBAS' of the BLPU dataset[14], 'S' (representing 'a small user, e.g. a residential property') from the header 'POSTCODE_T' of the DPA dataset[15], '2' (representing buildings 'in use') from the header 'BLPU_STATE' of the BLPU dataset[16] and the multiple occupancy count of the BLPU dataset with the header 'MULTI_OCC'[17]. Third, joint the cleaned OS AddressBase Premium data with the selected residential buildings of the UKBuildings data in ArcGIS, and then calculate the number of Household Spaces of residential buildings to represent the number of households by adding '1' to 'MULTI_OCC' dataset in Attribute Table. In this case, the selected 118,086 buildings are residential buildings in use and with independent postal address of small user. Thus, the number of multiple occupancy count of each residential building plus '1' can represent the number of Household Spaces in each residential building in Newcastle. The number of Household Spaces was then calculated for each residential building in the city.

The fifth step was the creation of the boundaries of the 910 Output Areas in the city. The boundary data was downloaded from the Boundary Data Selector of the UK Data Service website[18]. The sixth step was the creation of the database for the 2011 population weighted centroids of the 910 Output Areas of the city, which was downloaded from the Office for National Statistics website[19].

[13] Rather than '2' representing 'Non-Residential Building' from the header 'RNR', or '4' representing 'Not Populated/Unknown' from the header 'RNR'.
[14] Rather than 'N' representing 'not a postal address, 'C' representing 'a record which is postal and has a parent record, or 'L' representing 'a record which is identified as postal based on Local Authority information from the header 'ADDRESSBAS' of the BLPU dataset.
[15] Rather than 'L' representing 'a large user, e.g. a large commercial company from the header 'POSTCODE_T' of the DPA dataset.
[16] Rather than '1' representing 'Under Construction', '3' representing 'Unoccupied/Vacant/Derelict', '4' representing 'Demolished and '5' representing 'Planning Permission Granted'.
[17] '0' of 'MULTI_OCC' counts as 1 Household Space, meaning the residential building is not a multiple occupancy; '1' of 'MULTI_OCC' counts as 2 Household Spaces in one residential building, etc.
[18] https://census.ukdataservice.ac.uk/get-data/boundary-data
[19] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html

5.2.2 Justifications for Variables and Data Used

Variables and datasets were selected based on literature review and the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) adopted in this research. The following are justifications for variables and data that have been used in this research.

- **Travel Mode and Physical Distance (maximum distance threshold)**

- ***Walking as travel mode using road and urban paths networks***: Because the Deprived Household is less likely to own a car, and some may even have difficulties in affording public transport, and the existing related research has used car and/or public transport travel as the travel mode using road networks rather than using road and urban paths networks
- ***Half a mile as the maximum walking distance threshold***: Because this is often regarded as the ceiling for elderly walkers and mothers with preschool children (Hillman *et al*., 1973)
- ***Network distance rather than straight line distance***: Because the former is closer to reality as most people use road networks and urban paths to reach services (Christie and Fone, 2003)

- **Socio-economic Factor Used for Measuring the *Need Conception***

- ***Deprivation***: Because the socio-economic factors including employment, income, education, disability and housing, etc. that are reflected in the concept of deprivation reflecting needs (Hart, 1971)
- ***2011 Census Data deprivation dataset***: Because the four characteristics of households (Employment, Education, Health and Disability, and Housing) reflect socio-economic status (Figueroa et al., 2002; Gregory et al., 2000; Love and Lindquist, 1995; Office for National Statistics, 2011), which can be used to measure both the Deprived Household and the Non-Deprived Household (while other deprivation indices such as IMD and SIMD can only be used to measure deprivation and the extent of deprivation; they are not appropriate to compare which area is more deprived than others.)

- **Demographic Factor Used for Measuring the *Demand* Conception**

- ***Age group***: because different age groups may have access to healthcare services at different levels or frequency (e.g. consultation rates), which reflects demands (Rogers, *et al*., 1999; Scaife et al., 2000).

- ***The age groups under 5 and over 74 represent the Heavy User Group and the rest age groups at 5-74 represent the Light User Group***: Because these two age groups can represent higher and lower levels of demand for GP practices that are reflected in consultation rates (Rogers, *et al*., 1999). There are two age groups who are disproportionately large users of healthcare services in general – the elderly and young children (Kovar, 1986; Rogers, *et al*., 1999). For the elderly, the percentage of the aged who are 65-69 is decreasing while the percentage of those who aged 75 and over is increasing; for young children, parents with young children aged 0-4 are more likely to be frequent healthcare service attenders compared to parents with young children over 5 years old (Scaife et al., 2000). Thus, people of the age groups, the young children under 5 and the elderly aged 75 and over are selected as the Heavy User Group and the rest of age groups at 5-74 are selected as the Light User Group.
- It is worth noting here that the age groups of the young children under 5 and the elderly aged 75 and over are combined as the Heavy User Group based on their higher consultation rates of GP practices compared to the rest of age groups at 5-74 as the Light User Group on their lower consultation rates for potential access measurement and spatial equity assessment according to the *equality* and *demand* conceptions. It doesn't mean that the young children under 5 and the elderly aged 75 and over have the same demands. Rather, they both have higher consultation rates of GP practices compared to the rest of age groups.

- **GP Practices and the Number of FTE GPs**

- ***Walk-in centers are not counted as GP practices***: Because unlike GP practices, walk-in centers require no registration and provide limited scope of healthcare services, and some of them are nurse-led rather than GP-led
- ***All GP practices are counted in the city without the distinction between GP surgeries and satellite units***: Because there is no obvious distinction between GP surgeries and satellite units in terms of availability particularly when they are measured by the number of GPs or FTE GPs
- ***Using the number of FTE GPs as the indicator to measure the size of a GP practice***: Because the number of FTE GPs takes into consideration working hours of GPs in each GP practice, which is closer to reality than the number of GPs

It is worth noting here that a household can be either a Deprived Household or Heavy User Group, or both. The percentage of potential access by each social group classified by deprivation reflecting needs and age group reflecting demands (through consultation rates) will be measured according to the *equality* and *need* conceptions and the *equality* and *demand* conceptions separately on the city scale. Higher percentages of the Deprived Household and the Heavy User Group with lower percentages of potential access will be selected together to identify GP practices that may need to increase the size and or the quality in order to take into consideration the interaction between the two social groups reflecting needs and demands.

5.2.3 Data Analysis

For data analysis, the research contains the following two phases using GP practices in Newcastle as a case study. In the first phase, the proposed HSW technique and the PWC technique were illustrated and compared in terms of population estimation inside the merged Service Areas of all GP practices in Newcastle. The purpose was to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas. Then, the two techniques were further compared in the context of the application of the PWC and HSW methods to measure potential accessibility and potential access (the percentage of potential accessibility at the Service Area level multiplied by size weighting of each GP practice) to all GP practices in Newcastle. After that, the results of the application of the two methods were compared to demonstrate that the HSW method is more accurate than the PWC method in potential accessibility and potential access measurement.

In the second phase, the spatial equity assessment of GP practices in Newcastle was illustrated using the results from the application of the HSW method integrating the quality of GP practices based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). After that, the whole process was summarized from how to measure potential accessibility integrating size to how to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework applying the HSW method. This led to the development of the GIS-based Spatial Equity Assessment Framework. Also summarized was how to use the result from spatial equity assessment to provide policy recommendations on which GP practices may need to increase size and/or improve quality for cities on the city scale.

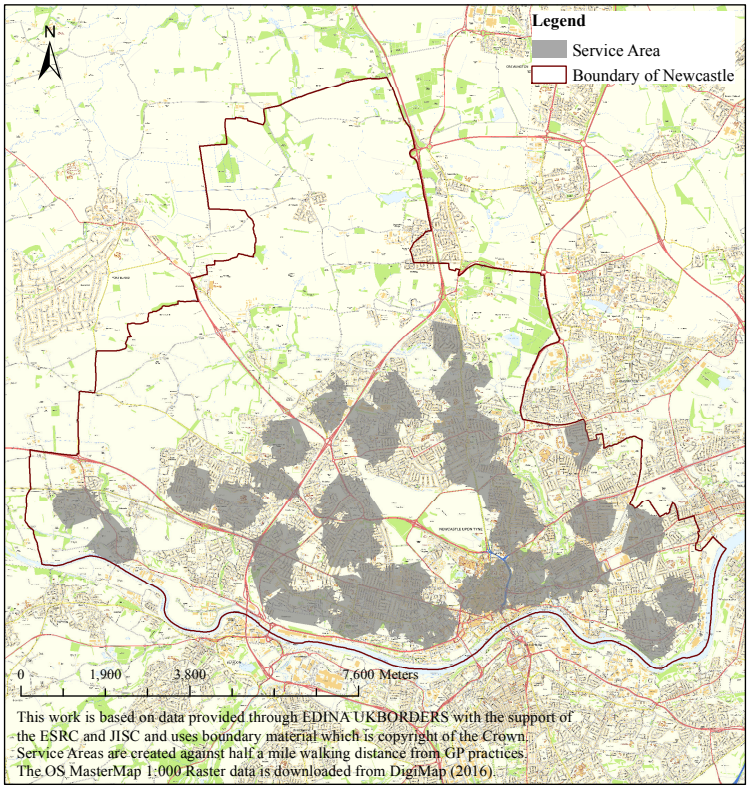
For both HSW and PWC techniques and the HSW and PWC methods, Service Areas of all GP practices in Newcastle were created individually by performing GIS Network Analyst using half a mile walking distance as the maximum walking distance threshold. For the application of the HSW and PWC techniques, the Service Areas were merged as one layer; for the application of the PWC and HSW methods, individual Service Areas were used. As to the assessment of spatial equity integrating the quality of GP practices, the individual Service Areas of GP practices were classified by quality, from which the Service Areas of GP practices with good quality (combining GP practices with 'Good' and 'Outstanding' CQC ratings) were selected for separate assessment.

The creation of the Service Areas followed four steps. First, clean the OS ITN Road and Urban Paths Networks dataset for Newcastle by performing the 'Multipart to Single Part' function to convert the polylines to single network segments, and further clean the dataset to make sure that there are end points while no overlays between polylines and no incorrect junctions. Second, edit the cleaned dataset in Attribute Table of ArcGIS by adding a field with Length ('Mile') and Type ('Float') and clicking on 'Calculate Geometry' choosing 'Mile' to do the calculation to obtain the distance dataset in mile. Third, export the cleaned OS ITN Road and Urban Path dataset to create network dataset to a connected folder, and right click on the exported feature dataset and click on 'New Network Dataset' to create new network. Fourth, create Service Areas for each of the 44 GP practices in Newcastle individually, from which the Service Areas of GP practices with 'Good' and 'Outstanding' CQC ratings were selected. The process of performing the Network Analyst followed four steps. First, click on 'New Service Area' of the 'Network Analyst Window' to display the 'Network analyst Panel. Second, right click on 'Facilities' and then left clink 'Load Locations' to load each GP practice at a time. Third, right click on 'Service Area Properties' to make changes to 'Polygon Generation' by unchecking 'Trim Polygons' and checking 'Overlapping'[20] and 'Disks'[21] for 'Overlapping Type', and then make changes to 'Analysis Settings' by selecting 'Distance (mile)' and adding 0.5 mile as 'Default Breaks'. Fourth, click on 'Solve' to display the Service Areas.

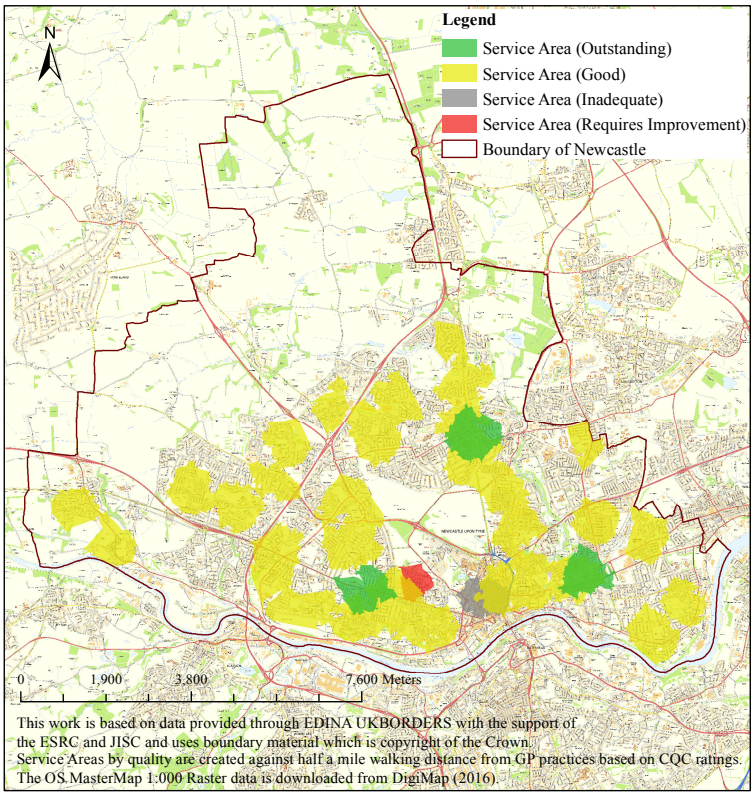
[20] 'Create polygons for each facility. These polygons may overlap'.
[21] 'Create the polygon going from the facility to the break'.

The Service Areas created for all GP practices and GP practices by quality ('Outstanding', 'Good', 'Inadequate' and 'Requires Improvement' CQC ratings) can be referred to Map 5 and 6.

Map 5 The Service Areas of All GP Practices in Newcastle



Map 6 The Service Areas of the GP Practices by Quality in Newcastle



The HSW and PWC techniques and methods were applied based on the Network Analysis technique mentioned above. The HSW and PWC techniques were applied to estimate population inside Service Areas; the HSW and PWC methods were applied to calculate the number and percentage of potential accessibility and the percentage of potential access to all GP practices for the four variables representing social groups (i.e. the Deprived Household and the Non-Deprived Households selected based on the *equality* and *need* conceptions and the Heavy User Group and the Light User Groups selected based on the *equality* and *demand* conceptions of the conceptual framework of spatial equity adopted in this research).

For the PWC method, the *Have Their Centre In* criterion was applied, that is Output Areas with population weighted centroids located inside Service Areas were counted as with access, otherwise without access. For the HSW method, population weighting technique was applied, that is Output Areas with all Household Spaces located inside Service Areas were counted as with full access, Output Areas with parts of Household Spaces located inside Service Areas were counted as with partial access, and Output Areas with no Household Space located outside Service Areas were counted as without access. For each Output Area with partial access, a weight was assigned in accordance with the number of Household Spaces (calculated based on the number of Houses in Multiple Occupancy of residential buildings in use to represent the number of Households) located inside the overlap of the Output Area and Service Areas dividing by the total number of Household Spaces located inside the Output Area.

For both methods, the number of each social group with potential accessibility by Service Area in the city (the numerator) was calculated by multiplying the weight of each Output Area with access by the total number of each social group within the Output Area, and then added up the results of all Output Areas with potential accessibility for each Service Area in the city. The percentage of each social group with potential accessibility by Service Area in the city was calculated by dividing the numerator by the total number of each social group involved in the calculation of the numerator taking into account the overlay of Service Areas on the city scale. The percentage of potential access was then calculated based on the percentage of potential accessibility integrating the size of healthcare services (size weighting) using the number of FTE GPs as an indicator to represent the size of GP practices. The size weighting was calculated following three steps. First, update the number of FTE GP data in Newcastle based on the latest General

Practice data (September 2016). Second, calculate the total number of the FTE GPs in the city. Third, calculate the size weighting for each GP practice by dividing the number of FTE GP of each GP Practice by the total number of the FTE GPs in the city. The percentage of each social group with potential access to all GP practices was then calculated by multiplying the percentage of each social group with potential accessibility to all GP practices by Service Area by the size weighting of each GP practice in the city on the city scale.

It is worth noting here that as the size of GP practices (the measurement of *Availability* using the number of FTE GPs as the indicator) is incorporated into the analysis to measure potential access in a way that is closer to reality, it is necessary to take into account the overlay of different Service Areas in the measurement as well. Because apart from the size of GP practices, the location of population and social groups inside or outside the overlay of Service Areas can affect the level of potential access as well. Population and social groups located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003).

The second phase of the data analysis emphasized spatial equity assessment and its application to provide policy recommendations. For the assessment of the *equality*, *need* and *demand* conceptions of spatial equity, the percentages of the Deprived and Non-Deprived Households and the Heavy and Light User Groups with potential access to all GP practices and GP practices of good quality by Service Area were compared respectively. The SPSS Mann-Whitney U was performed to test the difference when the percentage of the Deprived Household or the percentage of the Heavy User Group with potential access is higher than the percentage of the Non-Deprived Household or the percentage of the Light User Group. As SPSS Mann-Whitney U tests only report results in a two-tailed manner, the median values of the percentages of the two groups under comparison by Service Area were compared by performing the Frequencies to determine whether there is an equitable, equal or inequitable access to healthcare services, drawing upon Nicholls' (2001) research. The Mann-Whitney U only tests the significance of the difference, which may be not enough for it only examines the likeability of the findings are due to chance, so the effect size was calculated applying Cohen's Effect Size Index to understand the magnitude of differences. The combination of statistical significance and effect size can help understand the full impact of a study (Sullivan and Feinn, 2012).

For the assessment of the *equality* and *need* conceptions of spatial equity, a *need-based equitable access* was suggested when the percentage of the Deprived Household with potential access is significantly higher than the percentage of the Non-Deprived Household with potential access to healthcare services in a city; a *need-based equal access* was suggested when the percentage of the Deprived Household with potential access is higher than the percentage of the Non-Deprived Household with potential access to healthcare services in a city while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *need-based inequitable access* was suggested when the percentage of the Deprived Household with potential access is lower than the percentage of the Non-Deprived Household with potential access to healthcare services in the city on the city scale.

For the assessment of the *demand* conception of spatial equity, a *demand-based equitable access* was suggested when the percentage of the Heavy User Group with potential access is significantly higher than the percentage of the Light User Group with potential access to healthcare services in a city; a *demand-based equal access* was suggested when the percentage of the Heavy User Group with potential access is higher than the percentage of the Light User Group with potential access to healthcare services in a city while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *demand-based inequitable access* was suggested when the percentage of the Heavy User Group with potential access is lower than the percentage of the Light User Group with potential access to healthcare services in the city on the city scale.

Finally, the whole process was summarized from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) applying the HSW method. This led to the development of the GIS-based Spatial Equity Assessment Framework. The assessment framework was presented in a generic way as it has potential to extend from healthcare services to other services. Also summarized was how to use the result from spatial equity assessment to provide policy recommendations for cities on the city scale.

5.3 Reflexivity

5.3.1 Methodological and Empirical Limitations

There are several limitations of this research. First, there may be a small 'border effect' in this research as it does not include data on GP practices beyond but close to the

administrative boundary of Newcastle. But the research focuses on measuring potential accessibility and potential access to and spatial equity of healthcare services for cities on the city scale. It is more methodological rather than empirical as the aim of the research is to develop a spatial equity assessment framework for guiding the measurement of potential access and spatial equity assessment on the city scale using GP practices in Newcastle as a case study.

This has two main implications. First, measuring potential access to and assessing spatial equity of GP practices in Newcastle are a means to an end, not an end in itself even though they are measured and assessed in a most precise way using the most accurate and updated datasets available. Second, on the city scale in this research means that the research considers a city as a platform, which means that the city within its administrative boundary is the study area rather the city and its surrounding areas.

Despite all of the above, the 'border effect' is still considered as a limitation from the empirical perspective. To overcome the limitation, some existing studies have proposed possible solutions to the 'edge effect'. For instance, Luo and Wang (2003) and Wan *et al*. (2012) have proposed to use a buffer zone near the boundaries of the study area to account for the 'edge effect' (e.g. a 60-minute buffer zone was identified for the borders of the study area in Wan *et al*.'s (2012) study). The distance for creating the buffer zone can be the same as the distance used for creating the Service Area performing the GIS Network Analyst (such as half a mile walking distance as in this research).

Second, due to the absence of individual level census data, the research uses the number of Household Spaces to represent the number of households for the calculations of potential accessibility and potential access when applying the HSW technique. The technique is not a limitation itself by using the number of Household Spaces to represent the number of households. The limitation could be that it is the household level rather than the individual level that it aggregates the data into. However, in the case of the absence of the house level census data, the problem should be small as the calculations involve population weighting using currently the most accurate cadastral and address-based data as its ancillary data at the household level taking into consideration different dwelling types and multiple occupancy counts of residential buildings in use to represent the Household Space. And the number of Household Spaces rather than the location of each Household Space is used to represent the number of households within the Service Area.

Third, the research only takes socio-spatial perspective to investigate access to healthcare services, which means it only adopts *availability* and *accessibility* out of the five dimensions of access (*availability*, *accessibility*, *accommodation*, *affordability* and *acceptability*). Aspatial dimensions of access that could be more quality are not included into the measurement. Spatial equity is assessed based on the results of access measurement. This is a limitation of this research and many other existing studies for not including aspatial factors into access measurement. Potential solutions could be taking a combined quantitative and qualitative approach to include both socio-spatial and aspatial perspectives.

Fourth, the research only focuses on potential access rather than realized access (or utilization) due to the unavailability/accessibility of patient-level GP utilization data. This may be worth further research when related data is available.

5.3.2 Further Research

There are three aspects that may deserve further research. The first aspect is to expand the research from potential access to realized spatial access (may use patient-level consultation rates data if the data is available) to healthcare services particularly GP practices of the same case study city (Newcastle) on the city scale, compare the association between the results of the potential access and realized spatial access, and assess spatial equity using the GIS-based Spatial Equity Assessment Framework. The result from the realized spatial access measurement and spatial equity assessment could be useful to further inform urban planners and policy makers of priorities that could be given to GP practices that may need to increase size and/or improve quality.

The second aspect is the association between mobility and access by urbanity/rurality particularly in cities where the level of access is much lower in rural areas compared to urban areas using half a mile as the maximum walking distance threshold. In that case, different threshold standards may need to be used for measuring potential access in rural areas according to population densities. Factors related to mobility, such as car ownership, the existence and frequency of public transport; and the implications of the establishment of satellite surgeries may also be worth further investigating.

The third aspect is extending the assessment framework from healthcare services to other services and may use individual level big data to measure realized spatial access and then assess spatial equity applying the assessment framework.

5.4 Summary

In this chapter, the whole design of the research as well as the process of data preparation and analysis were illustrated. The chapter began with data preparation and justifications for variables and data used using GP practices in Newcastle as a case study.

It then focused on the research design for the two-phase data analysis process of the case study: i) the demonstration that the HSW technique is more accurate than the PWC technique in population inside Service Areas by illustrating and comparing the two techniques, and that the HSW method is more accurate than the PWC method in potential accessibility and potential access measurement; and ii) the illustration of how to assess spatial equity integrating quality based on the result of potential access measurement, and how to provide policy recommendations using the result of spatial equity assessment.

After that, the whole process was summarized from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) applying the HSW method. The summary led to the development of the GIS-based Spatial Equity Assessment Framework. Also summarized was how to use the result from spatial equity assessment to provide policy recommendations on which GP practices may need to increase size and/or improve quality for cities on the city scale. These offer a basis for the next two data analysis chapters, with each chapter focusing on one phase of data analysis that has been illustrated in this chapter.

Chapter Six: The Illustration and Comparison of the HSW and PWC Techniques in Population Estimation and Potential Accessibility Measurement, and Illustration of Potential Access Measurement

6.1 Overview

This chapter will focus on the illustration and comparison between the application of the HSW and PWC techniques in population estimation inside Service Areas and between the application of the HSW and PWC methods in potential accessibility and potential access measurement using GP practices in Newcastle as a case study. The purposes of the chapter are to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas, and the HSW method is more accurate than the PWC method in potential accessibility and potential access measurement. The result from the application of the more accurate method for measuring potential access will then be used to illustrate how to assess spatial equity integrating the quality of healthcare services in the next chapter.

There are six main sections in this chapter. Section Two to Three will emphasize the application of the HSW and PWC techniques to make population estimation inside Service Areas and the comparison between the results from the application of the two techniques. Section Four will illustrate how to take into account the overlay of Service Areas in potential accessibility measurement by adapting the conceptual diagram from Luo and Wang's (2003) research on how to apply the 2SFCA method taking into consideration the overlay of different Catchment Areas (i.e. Service Areas) to calculate the physician-to-population ratios to measure potential access.

Section Five to Six will emphasize the application of the HSW and PWC methods to measure potential accessibility and potential access for social groups based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). Both methods will draw upon Nicholls' (2001) research on measuring absolute potential access using GIS-based network analysis; the PWC method will draw upon the research on applying the *Have Their Centre In* criterion using population weighted centroids rather than geographic centroids to represent census units. The two methods will be illustrated and compared to demonstrate that the HSW method is more accurate in potential accessibility measurement, and how to calculate the percentage of potential access integrating the size weighting using FTE GPs as an indicator. The result of the percentage of potential access on the city scale will then be used to assess spatial equity of GP

practices integrating quality for social groups on the city scale based on the conceptual framework in the next chapter.

Section Seven will focus on illustrating the implication of involving the overlay of Service Areas in population estimation and potential accessibility measurement using the results calculated in the previous sections. Statistical and geographical analysis will be made by comparing the percentages of population inside two individual Service Areas of GP practices and the two overlaid Service Areas by Output Area in Newcastle on the city scale as an example.

6.2 Population Estimation Techniques

In this section, the application of the HSW technique and the PWC technique in population estimation inside Service Areas will be illustrated and compared. The purpose is to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas.

The Household Space Weighting (HSW) technique is a cadastral and address-based population weighting technique for estimating population inside Service Areas by spatially disaggregating the lowest available census data to the household level using ancillary data reflecting the number of Household Spaces (i.e. Houses in Multiple Occupancy of residential buildings by dwelling type in use) to represent the number of Households. The technique counts the proportion of Household Spaces within census units located inside Service Areas, and signs weights to census units with access accordingly, i.e. census units with all Household Spaces located inside Service Areas are counted as with full access, census units with parts of Household Spaces located inside Service Areas are counted as with partial access, and census units with no Household Space located inside Service Areas are counted as without access.

Similar to the CEDS technique proposed by Maantay et al. (2007) reviewed earlier in Chapter Three, the HSW technique does not use areal weighting or the binary technique to estimate population, neither using remotely sensed land cover/land use data to estimate population density classes. These have been demonstrated as advantages compared to other dasymetric mapping techniques including the Filtered Areal Weighting techniques in terms of disaggregating data and making population estimation inside Service Areas (Maantay et al., 2007).

However, the CEDS technique is developed based on the absence of the household level spatial data rather than using the combination of the most updated cadastral and address-based data. This leads to the main difference between the two techniques. The CEDS technique uses Residential Areas and the number of Residential Units as proxies for population distribution, with the assumption that the areas with more potential living accommodations have larger populations. It estimates population in a target area (the Buffer or Service Area in the case of performing Network Analyst) by disaggregating population from a higher to a lower level census unit (i.e. the Tax Lot) and then applying the *Have Their Centre In* criterion. The CEDS technique assigns the weight of '1' to the Tax Lots with their centroids located inside target areas and the weight of '0' to the Tax Lots with their centroids located outside target areas, and then calculates and adds up associated populations of those Tax Lots assigned weights of '1'.

The use of the centroids and the weight of either '1' or '0' here is a source of aggregation errors. Because it is not likely that the population of the Tax Lots located either inside or outside target areas. Rather, the population of the Tax Lots locate fully or partially inside target areas or located outside the target areas due to the uneven distribution of population located within the Tax Lots (i.e. the lower level census units that the CEDS technique has disaggregated to).

In comparison, the HSW technique estimates population in target areas (or Service Areas) by disaggregating population from the lowest available census units (Output Areas in the UK context) to the household level using the most updated and accurate cadastral data (the residential buildings of the UKBuildings data) and address-based data (the OS AddressBase Premium data) as its ancillary data. It takes into consideration different dwelling types and multiple occupancy counts of residential buildings in use. Instead of assigning the weight either '1' or '0', the HSW technique calculates the number of Household Spaces (to represent the number of households) and assigns weights to the lowest level census units according to their proportions of Household Spaces within census units located inside Service Areas. This means that the HSW technique assigns the weight of '1' to the lowest level census units with all Household Spaces located inside Service Areas, assigns the weight of '0-1' to the lowest level census units with partial Household Spaces located inside Output Areas, and assigns the weight of '1' to the lowest level census units with no Household Space located inside Output Areas. In this way, the HSW technique can be used as an alternative technique to reduce the

aggregation errors caused by the use of centroids to represent census units in population estimation inside Service Areas due to the unavailability of the house-level census data.

As the issue mentioned above while applying the CEDS technique is similar to the use of population weighted centroids to represent census units applying the PWC technique, it will be analyzed in detail later in the next section on the comparison between the application of the PWC and HSW techniques. The following paragraphs of this section will focus on the illustration of how to make population estimation inside Service Areas applying the HSW and PWC techniques using GP practices in Newcastle as a case study.

6.2.1 Population Estimation Applying the HSW Technique

As mentioned above, the Household Space Weighting (HSW) technique is a cadastral and address-based population weighting technique for estimating population inside Service Areas. It spatially disaggregates the lowest available census data to the household level and counts the proportion of Household Spaces within census units located inside Service Areas, and signs weights between '0' and '1' to census units with population inside Service Areas. The following is the three-step application of the HSW technique to make population estimation inside Service Areas.

The first step was the creation of the merged Service Areas of all GP practices in Newcastle. Service Areas of the 44 GP practices in the city were created individually and then merged as one layer following the steps illustrated in the Methodology Chapter. It is worth noting here that the purpose of merging the individual Service Areas here is to simplify the illustration of the HSW technique in this section, the illustration of the PWC technique and the comparison between the two techniques in the following two sections. The merge of individual Service Areas from multiple layers to one layer can avoid multiple counting of Output Areas in population estimation applying both techniques. Because the focus in the three sections is on illustrating the application the HSW and PWC techniques to make population estimation inside Service Areas and make comparison between the results of the two techniques rather than measuring potential accessibility and potential access for the case study. The measurement of potential accessibility and potential access will use individual Service Areas, the conceptual illustration and implications of which will be provided later in Section Four and Seven respectively.

After the creation of the merged Service Areas, residential buildings were selected based on the UKBuildings data for Newcastle purchased from the GeoInformation Group and

the AddressBase Premium data for the city provided by the Ordnance Survey. Three steps were followed to select residential buildings from all buildings in Newcastle before the calculation of the number of Household Spaces of residential buildings to represent the number of households in the city. First, Import the selected residential buildings of the UKBuildings dataset for Newcastle to ArcGIS. This was achieved by importing the shapefile format of UKBuildings dataset and clipping the dataset by Newcastle Boundary to ensure the inclusion of only Newcastle data. And then, select '1' (representing 'Residential Building') and '3' (representing 'Mixed Residential and Non-Residential Building') from the header 'RNR' (Residential/Non-Residential)[22] based on the Attribute Document of the UKBuildings using 'Select by Attribute' function in the Attribute Table.

Second, clean the OS AddressBase Premium datasets by selecting 'D' (representing 'a record which is linked to Royal Mail's postcode Address File') from the header 'ADDRESSBAS' of the BLPU dataset[23], 'S' (representing 'a small user, e.g. a residential property') from the header 'POSTCODE_T' of the DPA dataset[24], '2' (representing buildings 'in use') from the header 'BLPU_STATE' of the BLPU dataset[25] and the multiple occupancy count of the BLPU dataset with the header 'MULTI_OCC'[26].

Third, joint the cleaned OS AddressBase Premium data with the selected residential buildings of the UKBuildings data in ArcGIS, and then calculate the number of Household Spaces of residential buildings to represent the number of households by adding '1' to 'MULTI_OCC' dataset in Attribute Table. In this case, the selected 118,086 buildings are residential buildings in use and with independent postal address of small user. Thus, the number of multiple occupancy count of each residential building plus '1' can represent the number of Household Spaces in each residential building in Newcastle. The number of Household Spaces was then calculated for each residential building in the city.

[22] Rather than '2' representing 'Non-Residential Building' from the header 'RNR', or '4' representing 'Not Populated/Unknown' from the header 'RNR'.
[23] Rather than 'N' representing 'not a postal address, 'C' representing 'a record which is postal and has a parent record, or 'L' representing 'a record which is identified as postal based on Local Authority information from the header 'ADDRESSBAS' of the BLPU dataset.
[24] Rather than 'L' representing 'a large user, e.g. a large commercial company from the header 'POSTCODE_T' of the DPA dataset.
[25] Rather than '1' representing 'Under Construction', '3' representing 'Unoccupied/Vacant/Derelict', '4' representing 'Demolished and '5' representing 'Planning Permission Granted'.
[26] '0' of 'MULTI_OCC' counts as 1 Household Space, meaning the residential building is not a multiple occupancy; '1' of 'MULTI_OCC' counts as 2 Household Spaces in one residential building, etc.

This is key to disaggregate the census data from the lowest-level census unit available (i.e. output areas in this case) to the household level and calculate the number of household spaces to represent the number of households. Table 7 shows the datasets of UKBuildings and AddressBase Premium that were cleaned in the Attribute Table on ArcGIS for the disaggregating technique.

Table 7 Datasets Cleaned for Identifying Residential Buildings by Dwelling Type in Use Taking into Account Houses in Multiple Occupancy Count (Household Spaces) in Newcastle

Dataset Selected	Header Selected	Representation
UKBuildings Data		
'RNR' (Residential/Non-Residential)	'1'	'Residential Building'
	'3'	'Mixed Residential and Non-Residential Building'
AddressBase Premium Data		
BLPU (Basic Land and Property Unit)	'D' of 'ADDRESSBAS'	'a record which is linked to Royal Mail's postcode Address File'
	'2' of 'BLPU_STATE'	buildings 'in use'
	'MULTI_OCC'	'multiple occupancy count'
DPA (Delivery Point Address)	'S' of 'POSTCODE_T'	'a small user, e.g. a residential property'

Source: AddressBase Premium Data (Ordinance Survey, 2016) and UKBuildings (GeoInformation Group, 2016)

The second step was assigning weights to Output Areas with population located inside the Merged Service Areas. This was achieved by following two steps. First, create the overlap between each Output Area and the merged Service Areas by clipping each Output Area by the Service Areas in the city. Second, calculate the weight of each Output Area by dividing the number of Household Spaces located inside the overlap by the number of Household Spaces located inside the Output Area using the following equation.

$$\boldsymbol{W}_{i_m} = \frac{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \left\{ \boldsymbol{B_{MSA_c}} \cap \boldsymbol{B_{OA_i}} \right\}}{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \boldsymbol{B_{OA_i}}} \qquad \textbf{Equation 1}$$

Where,

$\boldsymbol{W}_{i_m}$ = The Weight of Output Area *i* with Household Spaces located inside the merged Service Areas in a city

$\boldsymbol{N_{HS}}$ = The number of Household Spaces

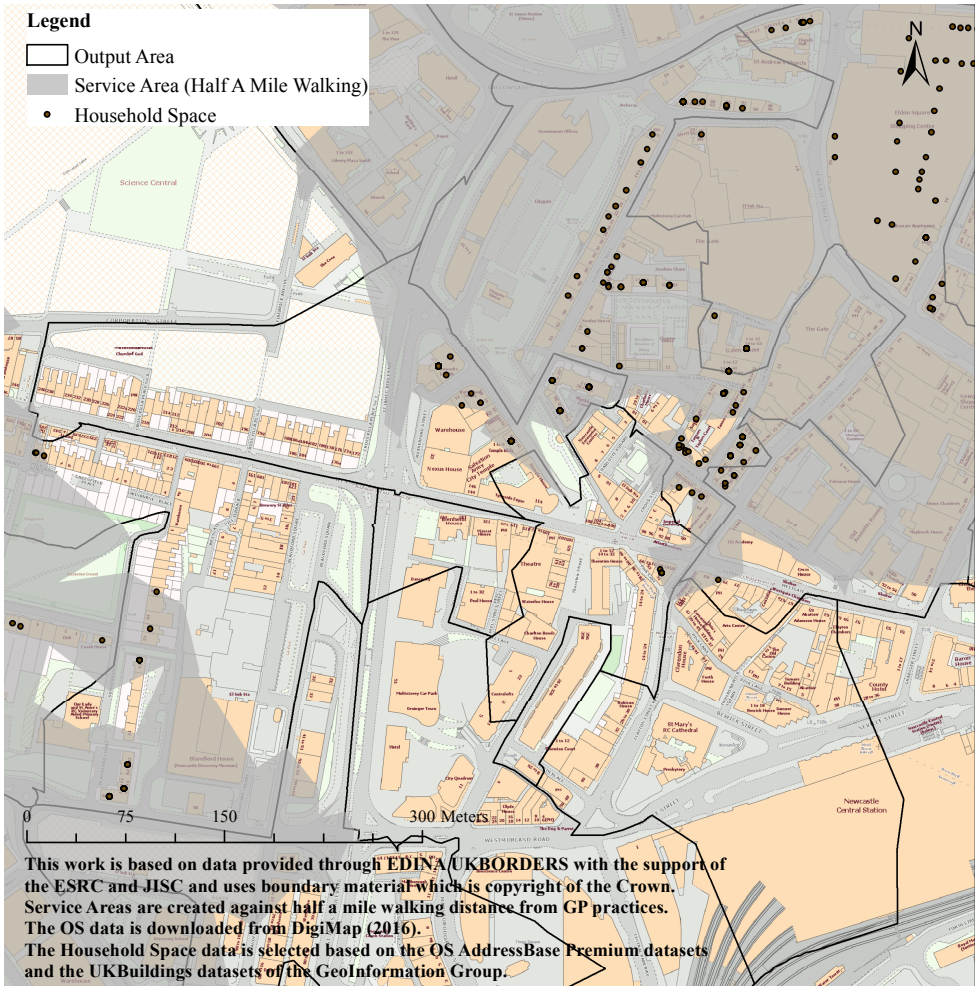
$\boldsymbol{B_{MSA_c}}$ = The Boundary of the Merged Service Areas in the city

$\boldsymbol{B_{OA_i}}$ = The Boundary of the Output Area *i*

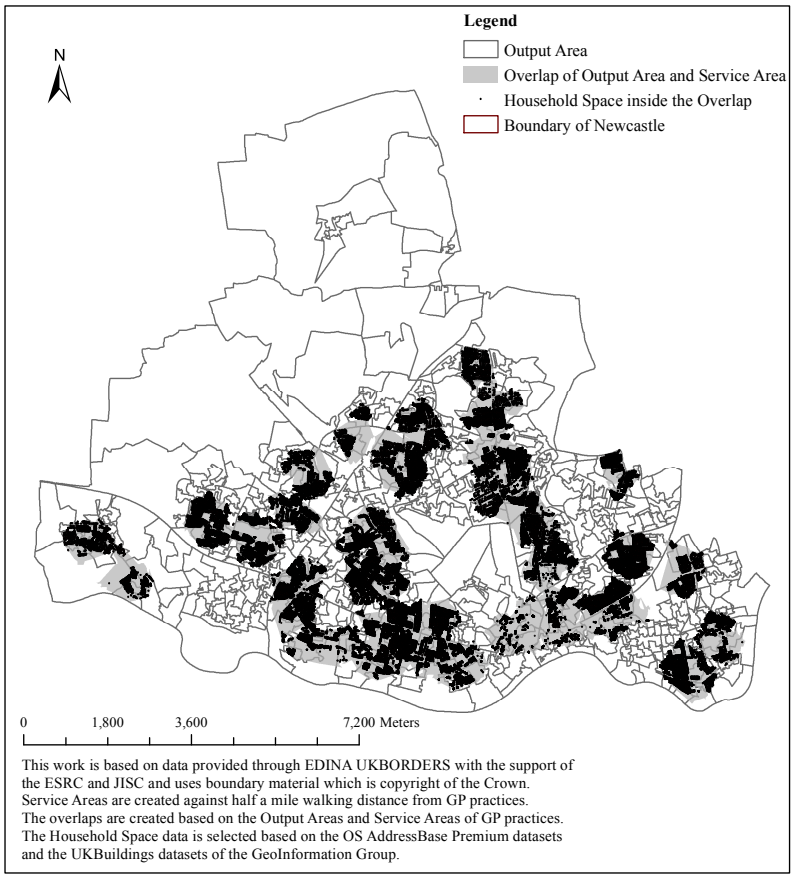
For an Output Area with no Household Space located inside the merged Service Areas, the weight is '0'; for an Output Area with parts of Household Spaces located inside the merged Service Areas, the weight is '0-1'; for an Output Area with all Household Spaces located inside the merged Service Areas, the weight is '1'.

Map 7 indicates examples of the location of residential buildings by dwelling type in use taking into account Houses in Multiple Occupancy (i.e. Household Spaces) inside the overlap of the Output Area and the merged Service Areas in an illustrative area of Newcastle applying the HSW technique. The identification of the location of residential buildings by dwelling type in use in the city is key to identify the location of Household Spaces. Map 8 shows the application of the HSW technique to estimate population inside the merged Service Areas of all GP practices in Newcastle on the city scale.

Map 7 Examples of Household Spaces Located inside the Overlap of the Output Area and Service Area in Newcastle



Map 8 The Application of the HSW Technique to Make Population Estimation inside the Merged Service Areas of All GP Practices in Newcastle



The third step was the calculation of population inside the merged Service Areas. Join the 2011 Census Data population dataset on the Output Area level with the weight dataset and calculate the population of each Output Area with Household Spaces located inside the merged Service Areas in Excel using the following equation.

$$\boldsymbol{P_{MSA_c}} = \sum_{i=1}^{n} (\boldsymbol{P_i W_{i_m}}) \qquad \textbf{Equation 2}$$

Where,

$\boldsymbol{P_{MSA_c}}$= Population located inside the merged Service Area in a city

$\boldsymbol{P_i}$ = Population of Output Area *i*

$\boldsymbol{W_{i_m}}$ = The Weight of Output Area *i* with Household Spaces located inside the merged Service Areas in a city

According to the Attribute Table in ArcGIS, there are 635 Output Areas with Household Spaces located inside the merged Service Areas of all GP practices in Newcastle applying the HSW technique. The dataset of the 635 Output Areas was then exported to Excel where the population inside the merged Service Areas of all GP practices in the city was

calculated by adding up the subpopulations calculated for each of the 635 Output Areas. The result of population estimation inside Service Areas is that there are 152,013 residents located inside the merged Service Areas of all GP practices in Newcastle applying the HSW technique. The population in each Output Area, the weight of each Output Area with access, the subpopulation in each Output Area and the total population located inside the merged Service Areas in the city applying the HSW technique can be referred to Appendix A.

6.2.2 Population Estimation Applying the PWC Technique

The Population Weighted Centroid (PWC) Technique is a population weighted technique for estimating population inside Service Areas using the population weighted centroids of census units when applying the *Have Their Centre In* criterion. It identifies census units with population weighted centroids located inside Service Areas, and signs weights of either '0' or '1' to census units with population inside Service Areas. As an existing technique to reducing aggregation errors caused by the use of geographic centroids to represent Output Areas, the PWC technique will be applied using population weighted centroids to represent Output Areas to estimate population inside the merged Service Areas of all GP practices in Newcastle. The following is the three-step application of the PWC technique to make population estimation inside Service Areas.

The first step was the same as in the application of the HSW technique, i.e. creating the merged Service Areas of all GP practices in Newcastle. As individual Service Areas had been created and merged during the illustration of the application of the HSW technique, the merged Service Areas were adopted for the illustration of population estimation applying the PWC technique here.

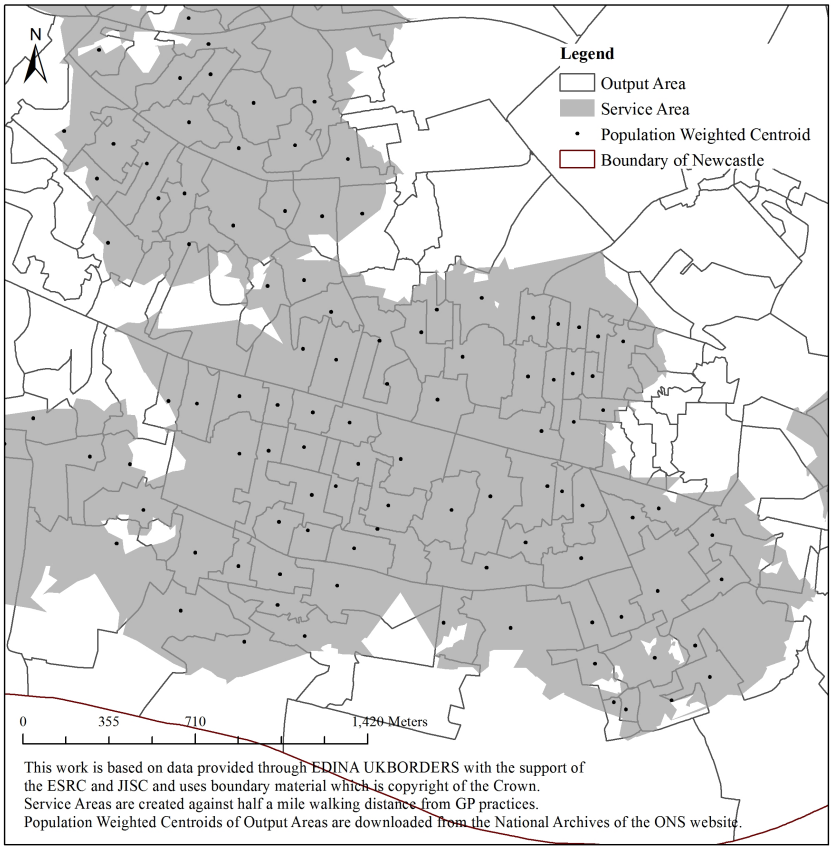
The second step was the application of the *Have Their Centre In* criterion to identify population weighted centroids inside the merged Service Areas, based on which to assign weights to Output Areas according to population weighted centroids located inside or outside Service Areas. This was achieved by clipping the population weighted centroids of the 910 Output Areas of Newcastle by the merged Service Areas in the city. For an Output Area with its population weighted centroid located outside the merged Service Areas, the weight of '0' was assigned; for an Output Area with its population weighted centroid located inside the merged Service Areas, the weight of '1' was assigned.

The third step was the same as in the application of the HSW technique, i.e. the calculation of population inside the merged Service Areas. Join the 2011 Census Data

population dataset on the Output Area level and then calculate population inside Service Areas for those Output Areas with their population weighted centroids located inside Service Areas.

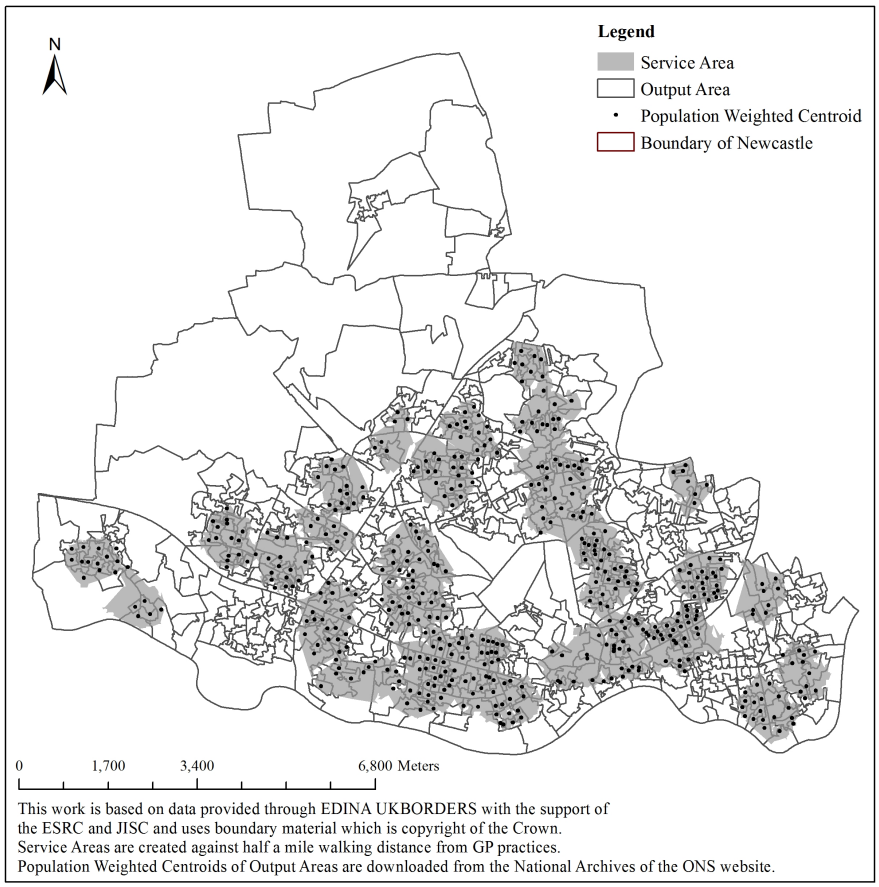
For the application of the PWC technique, as the data of the population weighted centroids of the 910 output areas is available in the UK, it was downloaded from the Office for National Statistics (ONS) website[27]. The identification of population weighted centroids inside service areas is the key to the calculation of the number of potential accessibility applying the PWC technique. This requires the identification of the relationship between the output area, the population weighted centroid and the service area in the city. Map 9 shows such relationship for an illustrative area of the city when applying the PWC technique. Map 10 indicates the application of the PWC technique to estimate population inside the merged Service Areas of all GP practices in Newcastle on the city scale.

Map 9 The Relationship among the Output Area, the Service Area and the Population Weighted Centroid inside Service Areas Applying the PWC Technique in Newcastle



[27] http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html

Map 10 The Application of the PWC Technique to Make Population Estimation inside the Merged Service Areas of All GP Practices in Newcastle



According to the Attribute Table in ArcGIS, there are 476 Output Areas with their population weighted centroids located inside the merged Service Areas of all GP practices in Newcastle. The dataset of the 476 Output Areas was then exported to Excel where population inside the merged Service Areas of all GP practices in the city was calculated by adding up the population of the 476 Output Areas. The result is that there are 150,975 residents located inside the merged Service Areas of all GP practices in Newcastle applying the PWC technique. The population in each Output Area, the weight of each Output Area with access, the subpopulation in each Output Area and the total population located inside the merged Service Areas in the city applying the PWC technique can be referred to Appendix B.

6.3 Comparisons of Population Estimation Applying the HSW and PWC Techniques

The application of the HSW and PWC techniques produces different results of population estimation inside the merged Service Areas of all GP practices in Newcastle. In this section, conceptual and empirical comparisons will be made between the application of the two techniques in population estimation inside the merged Service Areas of all GP

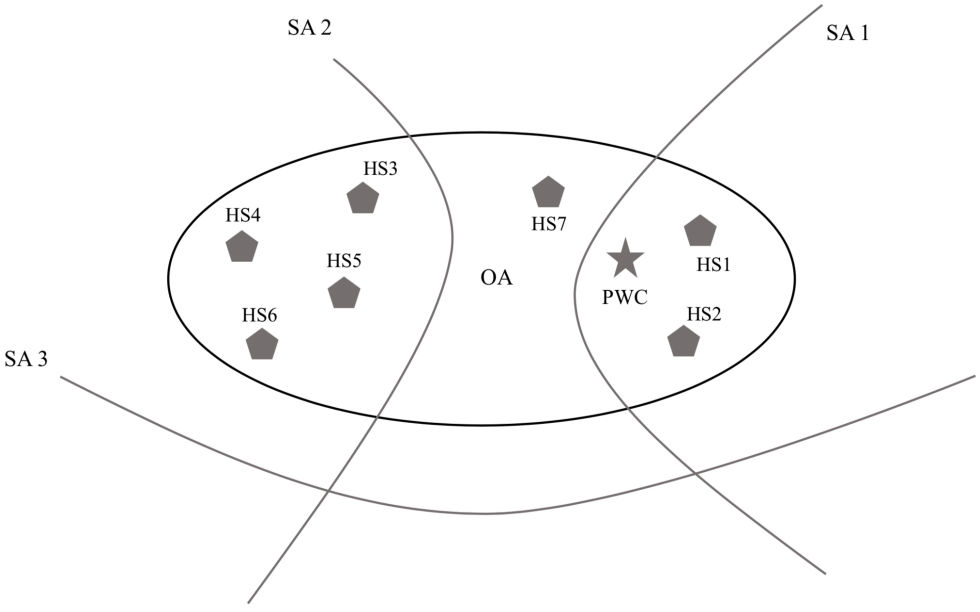
practices in Newcastle as an example. The purpose is to demonstrate that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas.

6.3.1 Conceptual Comparisons of Population Estimation Applying the Two Techniques

The conceptual comparisons will focus on analyzing the difference in weights assigned to Output Areas with population inside the merged Service Areas applying the HSW and PWC techniques. Figure 7 is a conceptual diagram showing the difference in weight assigned to Output Areas with population inside the merged Service Areas applying the two techniques.

In the diagram, the ellipse represents an Output Area, the curved lines represent Service Areas, the star represents the population weighted centroid of the Output Area and the pentagons represent Household Spaces. To simplify the illustration, only one Output Area was used, and one pentagon was counted as one Household Space. There are overlaps between the Output Area and Service Area 1 and between the Output Area and Service Area 2; the Output Area is fully located inside Service Area 3.

Figure 7 Conceptual Diagram on the Difference in Weight Assigned to Output Areas with Population inside the Merged Service Areas Applying the Two Techniques



Source: Own analysis

As can be seen from Figure 7, there are three scenarios concerning the relationship between the Output Area and Service Areas 1 to 3. First, inside the overlap of the Output Area and Service Area 1, there are 2 out of the 7 Household Spaces while the population weighted centroid of the Output Area is located inside the Service Area. This means that

the weight assigned to the Output Area with population inside the merged Service Area is '2/7' (i.e. '0-1') when applying the HSW technique, while the weight assigned to the Output Area with population inside the merged Service Area is to '1' when applying the PWC technique. Second, inside the overlap of the Output Area and Service Area 2, there are 4 out of the 7 Household Spaces and the population weighted centroid of the Output Area is located outside the Service Area. This means that the weight assigned to the Output Area with population inside the merged Service Area is '4/7' (i.e. '0-1') when applying the HSW technique, while the weight assigned to the Output Area with population inside the merged Service Area is '0' when applying the PWC technique. Third, as the Output Area is fully located inside Service Area 3, the weights assigned to the Output Area with population inside the merged Service Area are both '1' when applying both techniques.

The following is a summary of how the weights are assigned to Output Areas with population located inside Service Areas in accordance with the three scenarios illustrated above:

i. when an Output Area overlaps with a Service Area with partial Household Spaces located inside the overlap while with the population weighted centroid of the Output Area located inside the Service Area (e.g. SA1), the weight of '0-1' is assigned applying the HSW technique and the weight of '1' is assigned applying the PWC technique to the Output Area with population inside Service Areas;
ii. when an Output Area overlaps with a Service Area with partial Household Spaces located inside the overlap and with the population weighted centroid of the Output Area located outside the Service Area (e.g. SA2), the weight of '0-1' is assigned applying the HSW technique and the weight of '0' is assigned applying the PWC technique to the Output Area with population inside Service Areas; and
iii. when an Output Area is fully located in a Service Area (e.g. SA3), the weight of '1' is assigned applying both the HSW and PWC techniques to the Output Area with population inside Service Areas.

Table 8 indicates the weights assigned to the Output Areas with population located inside Service Areas in accordance with the three scenarios applying the HSW and PWC techniques based on the relationship between the Output Area and Service Areas in the above conceptual analysis.

Table 8 Weights Assigned to the Output Areas according to the Three Scenarios Applying the HSW and PWC Techniques in the Conceptual Analysis

Service Area	Weight of OA Applying HSW Technique	Weight of OA Applying PWC Technique
Service Area 1	'2/7'	'1'
Service Area 2	'4/7'	'0'
Service Area 3	'1'	'1'

Source: Own calculation

As illustrated above, in the first two scenarios, different weights were assigned to the Output Area applying the HSW and PWC techniques. The way how the PWC technique assigning weights to Output Areas to make population estimation inside Service Areas can be a source of aggregation errors. For the PWC technique, the weight of '1' is assigned to Output Areas with their population weighted centroids located inside Service Areas, which assumes that the total population of the Output Areas are located inside the Service Areas; the weight of '0' is assigned to Output Areas with their population weighted centroids located outside Service Areas, which assumes that no population of the Output Areas is located inside the Service Areas. However, it is partial rather than total or no population located inside Service Areas as in scenario one and two in the conceptual analysis.

While for the HSW technique, the weight is assigned to an Output Area with population located inside Service Areas based on the proportion of Household Spaces (representing the number of Households calculated on the basis of the number of Houses in Multiple Occupancy of residential buildings by dwelling type in use) within the Output Area located inside Service Areas. In other words, apart from the weight of '0' or '1', the weight of '0-1' is assigned to Output Areas with partial population located inside Service Areas when applying the HSW technique.

6.3.2 Empirical Comparisons in Population Estimation between the Application of the Two Techniques

The following paragraphs will use empirical data to further explain the difference in how weights are assigned applying the two techniques in accordance with the three scenarios particularly the first two scenarios and the occurrence of aggregation errors applying the PWC technique. Out of the 910 Output Areas in Newcastle, when applying the HSW technique, there are 310 Output Areas with total population located inside the merged Service Areas and 267 Output Areas with partial population located inside the merged Service Areas. While there are 476 Output Areas with total population located inside the

merged Service Areas when applying the PWC technique, of which there are 310 Output Areas with total population located inside the merged Service Areas and 136 Output Areas with partial population located inside the merged Service Areas when applying the HSW technique.

Thus, according to the three scenarios, there are 136 Output Areas falling into Scenario One where the weight of '0-1' was assigned to the Output Areas applying the HSW technique, while the weight of '1' was assigned to the Output Areas applying the PWC technique; there are 131 Output Areas falling into Scenario Two where the weight of '0-1' was assigned to the Output Areas applying the HSW technique, while the weight of '0' was assigned to the Output Areas applying the PWC technique; there are 310 Output Areas falling into Scenario Three where the weight of '1' was assigned to the Output Areas applying both the HSW and PWC techniques in the city. Table 9 shows the weights and the number of the Output Areas falling into the three scenarios in Newcastle applying the HSW and PWC techniques.

Table 9 The Weight and Numbrer of the Output Areas Falling into the Three Scenarios in Newcastle Applying the HSW and PWC Techniques

Scenario	Weight of OA Applying HSW Technique	Weight of OA Applying PWC Technique	Number of OA
Scenario One	'0-1'	'1'	136 (Overestimation)
Scenario Two	'0-1'	'0'	131 (Underestimation)
Scenario Three	'1'	'1'	310

Source: Own calculation

Thus, out of the 910 Output Areas in Newcastle, the PWC technique produces inaccurate population estimation for the 267 (136+131) Output Areas as in reality only partial population rather than total population or no population of the 267 Output Areas located inside the merged Service Areas of all GP practices in the city. There is an overestimation when applying the PWC technique compared to the HSW technique in the first scenario and an underestimation when applying the PWC technique compared to the HSW technique in the second scenario.

To further compare the weights assigned to the 267 Output Areas in accordance with the first two scenarios, a table was created to compare the difference in the weights assigned to the Output Areas based on Scenario One and Scenario Two between the application of

the two techniques. Figure 8 is a screenshot of the table; the full table can be referred to Appendix C.

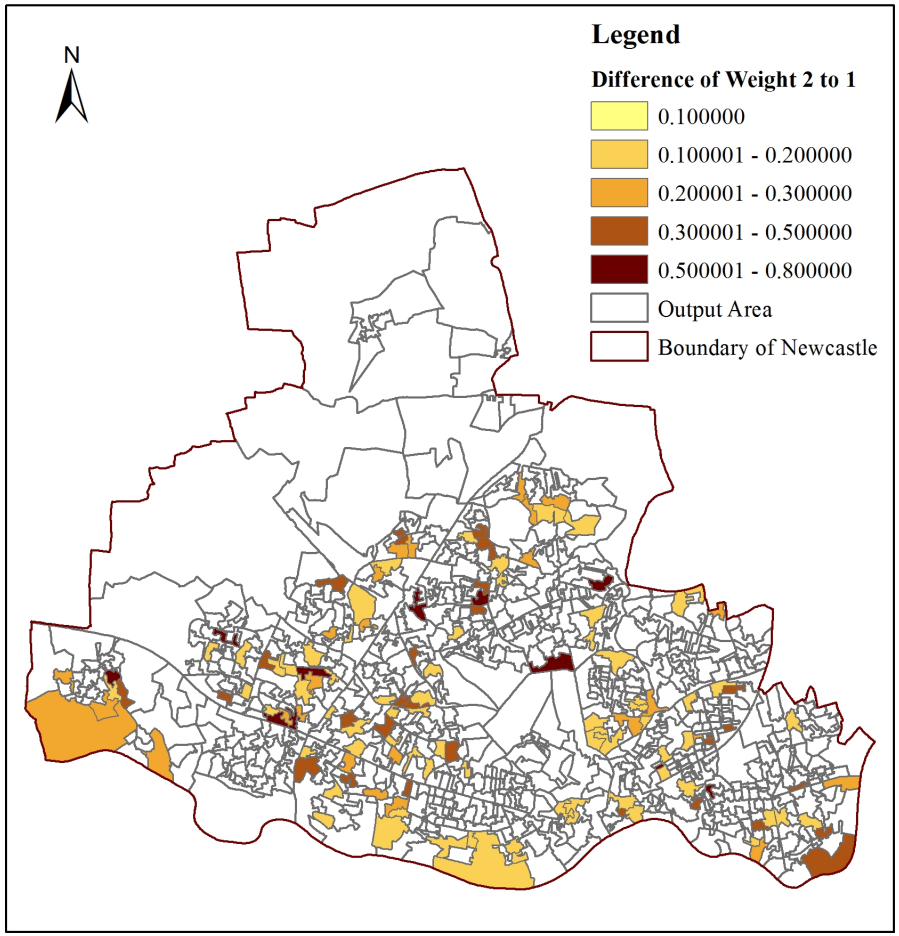
Figure 8 The Difference in the Weights Assigned to the Output Areas based on Scenarios One and Two between the Application of the HSW and PWC Techniques

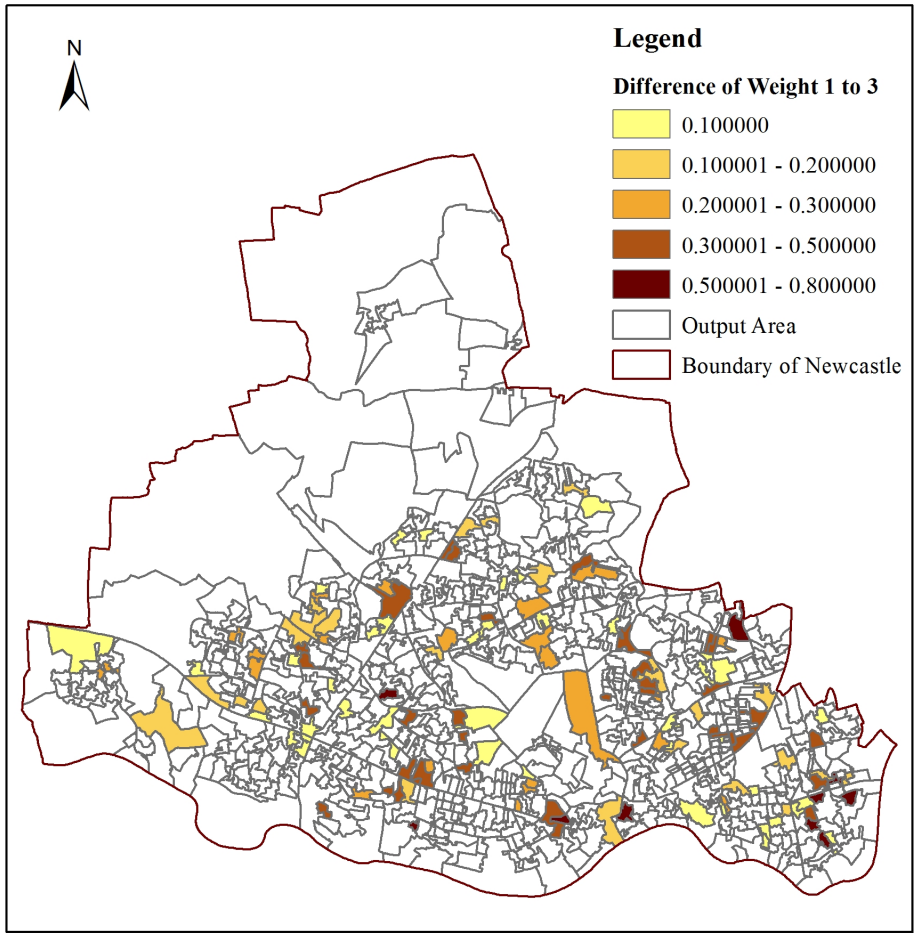
No.	OA Code 1	Weight 1_ OA with Partial Population inside the Service Areas_HSW	Weight 2_ OA with Total Population inside the Service Areas_PWC	Difference of Weight 2 to 1	OA Code 2	Weight 1_ OA with Partial Population inside the Service Areas_HSW	Weight 3_ OA with No Population inside the Service Areas_PWC	Difference of Weight 1 to 3
1	E00042043	0.5	1	**0.5**	E00042042	0.4	0	**0.4**
2	E00042046	0.8	1	**0.2**	E00042044	0.3	0	**0.3**
3	E00042048	0.7	1	**0.3**	E00042045	0.8	0	**0.8**
4	E00042052	0.7	1	**0.3**	E00042053	0.2	0	**0.2**
5	E00042056	0.9	1	**0.1**	E00042069	0.3	0	**0.3**
6	E00042057	0.7	1	**0.3**	E00042071	0.4	0	**0.4**
7	E00042070	0.8	1	**0.2**	E00042077	0.1	0	**0.1**
8	E00042073	0.4	1	**0.6**	E00042079	0.1	0	**0.1**
9	E00042078	0.7	1	**0.3**	E00042086	0.6	0	**0.6**
10	E00042082	0.9	1	**0.1**	E00042107	0.3	0	**0.3**

Source: Own analysis

In Figure 8, OA Code 1 represents the OA codes of the 136 Output Areas falling into Scenario One and OA Code 2 represents the OA codes of the 131 Output Areas falling into Scenario Two. Weight 1 represents the weight of the 136 Output Areas and the 131 Output Areas with partial population inside the merged Service Areas applying the HSW technique (i.e. the weight of '0-1'); Weight 2 represents the weight of the 136 Output Areas with total population inside the merged Service Areas applying the PWC technique (i.e. the weight of '1'); Weight 3 represents the weight of the 131 Output Areas with no population inside the merged Service Areas applying the PWC technique (i.e. the weight of '0'). Thus, subtracting the weights of '0-1' assigned to the 136 Output Areas applying the HSW technique from the weight of '1' assigned to the 136 Output Areas applying the PWC technique respectively yields the difference in weight 2 to 1 (i.e. the overestimation when applying the PWC technique); subtracting the weights of '0' assigned to the 131 Output Areas applying the PWC technique from the weight of '0-1' assigned to the 131 Output Areas applying the HSW technique respectively yields the difference in weight 1 to 3 (i.e. the underestimation when applying the PWC technique). Map 11 visualizes the distribution of the difference in weights assigned to the 136 and 131 Output Areas (the overestimation and underestimation) based on Scenario One and Scenario Two between the application of the HSW and PWC techniques in Newcastle.

Map 11 Visualization of the Distribution of the Difference in the Weights Assigned to the 267 Output Areas based on Scenario One and Scenario Two between the Application of the HSW and PWC Techniques In Newcastle (Quantile)



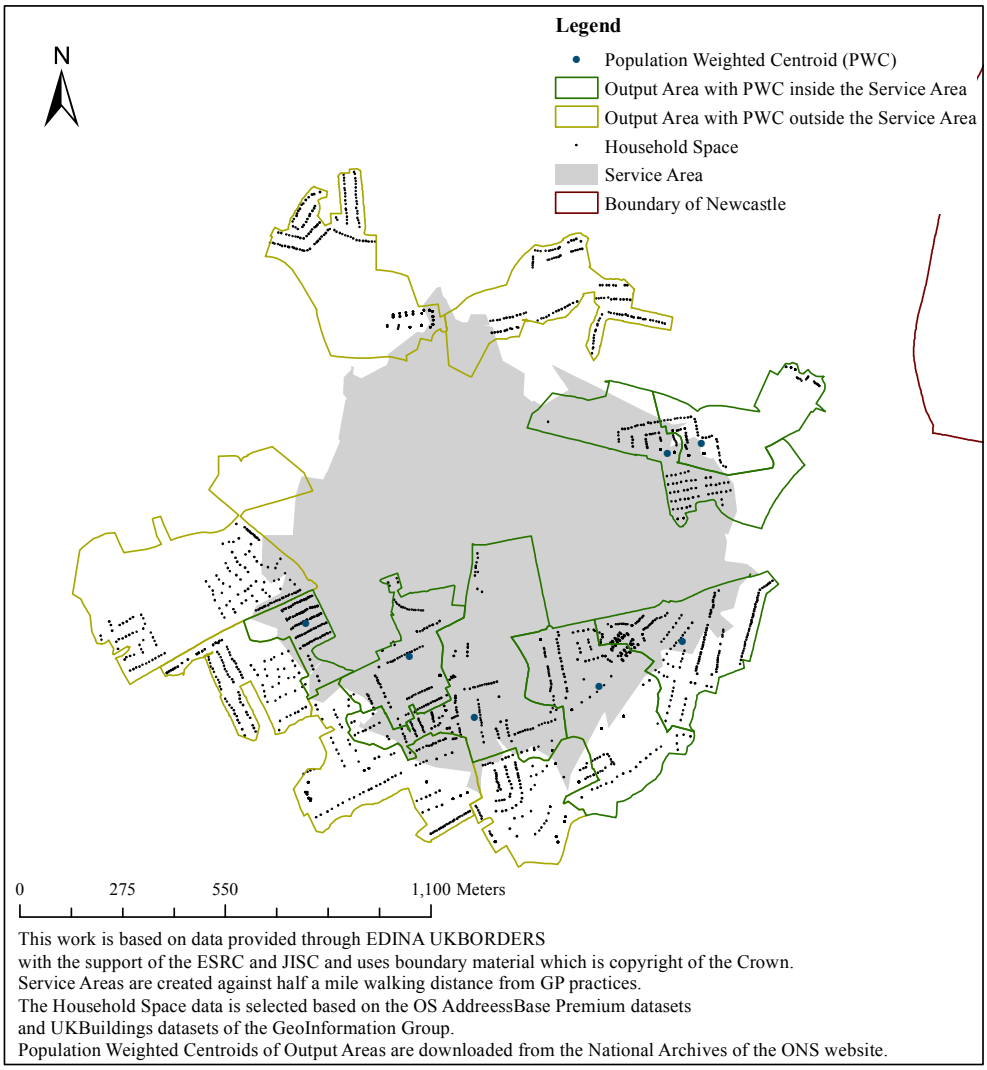


0 2,450 4,900 9,800 Meters

As can be seen from the comparative map that there are variations in the difference of the weighs assigned to Output Areas with population located inside the merged Service Areas between the application of the HSW and PWC techniques. The darker the color, the bigger the difference in the weights assigned to the same Output Areas applying the two techniques. The map on the left indicates the difference in the weight 2 to weight 1 assigned to the 136 Output Areas by subtracting the weight of '0-1' assigned to each of the 136 Output Areas with partial population located inside the merged Service Areas applying the HSW technique from the weight of '1' assigned to each of the 136 Output Areas with total population located inside the merged Service Areas applying the PWC technique. This represents overestimations of the 136 Output Areas with population located inside Service Areas when applying the PWC technique. The map on the right shows the difference in the weight 1 to weight 3 assigned to the 131 Output Areas by subtracting the weight of '0' assigned to each of the 131 Output Areas with no population located inside the merged Service Areas applying the PWC technique from the weights of '0-1' assigned to each of the 131 Output Areas with partial population located inside the merged Service Areas applying the HSW technique. This represents underestimations of the 131 Output Areas with population located inside Service Areas when applying the PWC technique.

To further visualize the difference and the occurrence of the aggregation errors, a Service Area of a random GP practice in the city was selected to compare the difference in the way how the weights of Output Areas with population located inside Service Areas are assigned and the over/underestimation at the Service Area scale between the application of the HSW and PWC techniques. Map 12 visualizes such difference and the location of the aggregation errors.

Map 12 Visualization of the Aggregation Error Issue at the Service Area Scale



As can be seen from Map 12 that there are Output Areas with population weighted centroids located inside the Service Area (in green color with the weight of '1') when applying the PWC technique while with only partial Household Spaces located inside the Service Area (with the weight of '0-1') when applying the HSW technique. On the other hand, there are Output Areas with population weighted centroid located outside the Service Area (in yellow color with the weight of '0') when applying the PWC technique while with partial population located inside the Service Area (with the weight of '0-1') when applying the HSW technique.

The dichotomous categorization of Output Areas either with total population or no population located inside Service Areas applying the PWC technique when making population estimation inside Service Areas is not true in reality. On the contrary, the HSW technique takes into account all the three categories, Output Areas with total population, partial population or no population located inside Service Areas using the

most accurate cadastral and address-based data as its ancillary data, which is closer to reality.

Based on the above conceptual, geographical and statistical analysis, the HSW technique has been demonstrated as more accurate in population estimation inside Service Areas compared to the PWC technique. In the following sections, the two techniques will be applied using individual Service Areas rather than the merged Service Areas of all GP practices in Newcastle in the context of the application of the PWC and HSW methods to measure potential accessibility and potential access. Further comparisons will be made between the two methods in the measurement of potential accessibility and potential access to all GP practices for social groups in Newcastle integrating size based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) in the upcoming sections.

Before the illustration of how to apply the HSW and PWC techniques in the context of the application of the PWC and HSW methods to measure potential accessibility of all GP practices in Newcastle, how to take into account the overlay of Service Areas in the context of using individual Service Areas (instead of the merged Service Areas) will be illustrated conceptually in the next section.

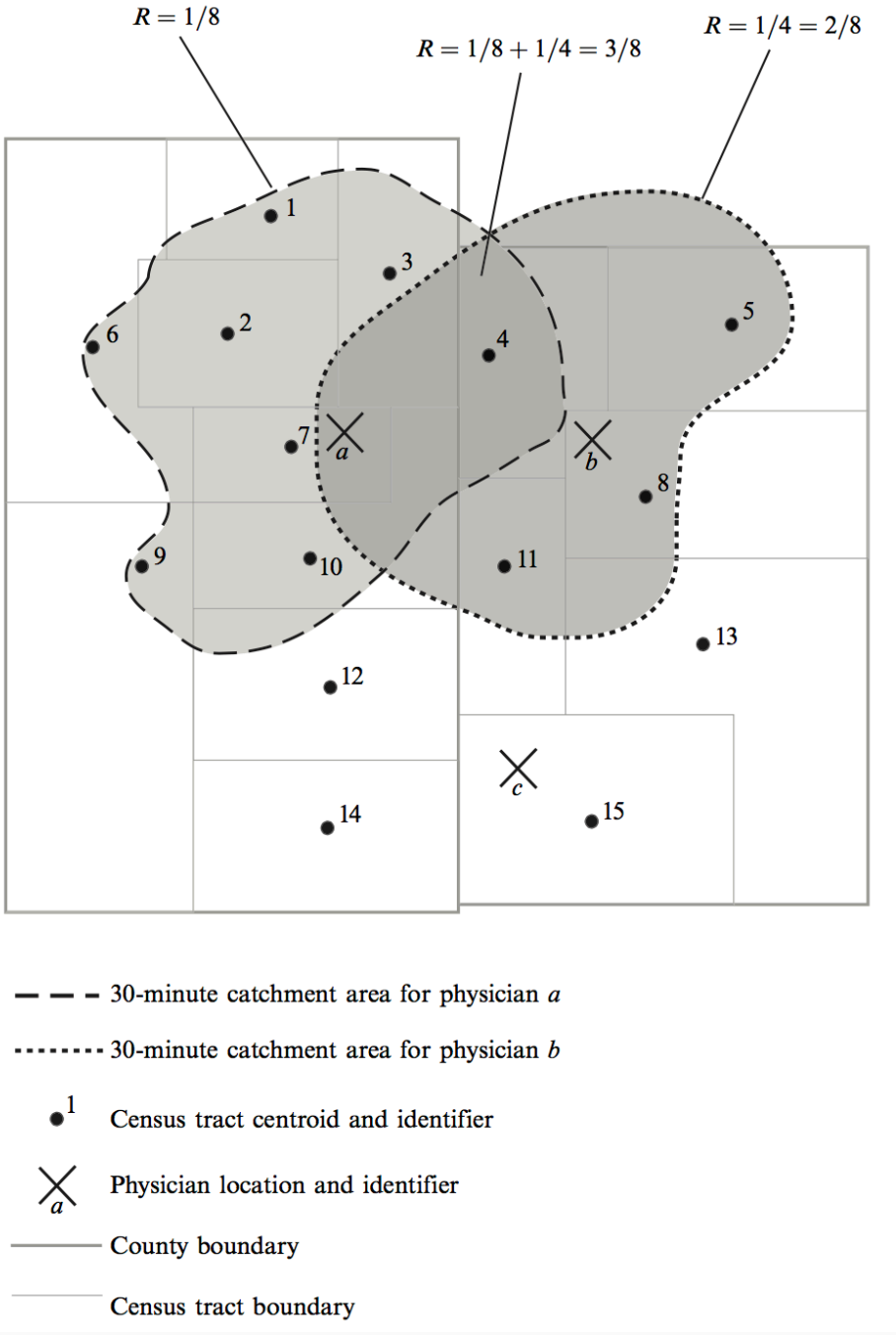
6.4 Conceptual Illustration of How to Take into Account the Overlay of Service Areas in Potential Accessibility Measurement

The process of calculating population and its subgroups (social groups) with potential accessibility is similar to that of population estimation inside the merged Service Areas illustrated earlier applying the HSW and PWC techniques. However, individual Service Areas rather than merged Service Areas will be used for the calculation of potential accessibility. Because the location of population and its subgroups inside the overlay of different Service Areas or inside only one of the Service Areas can affect the level of potential accessibility, thus influencing the result of potential access when the size of healthcare services is taken into account. Population and social groups located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003).

Thus, before the illustration of how to apply the HSW and PWC techniques in the context of the application of the PWC and HSW methods to measure potential accessibility, it is necessary to illustrate how to take into account the overlay of Service Areas in the

calculations. The research draws upon Luo and Wang's (2003) study on how to take into account the overlay of different Catchment Areas (Service Areas) to calculate the physician-to-population ratios for potential access measurement, the illustration of which can be referred to Figure 9.

Figure 9 Conceptual Diagram of How to Take into Account the Overlay of Catchment Areas in Potential Access Measurement Applying the 2SFCA Method



Source: Luo and Wang (2003:873)

As can be seen from Figure 9 that the Catchment Area for physician *a* has one physician and eight census tracts with their centroids located inside the Catchment Area of

physician *a*, thus producing a physician-to-population ratio of '1/8'. Similarly, the physician-to-population ratio for Catchment Area *b* is '1/4'. As census tracts 1, 2, 3, 6, 7, 9, and 10 only have access to physician *a*, the ratio for them equals '1/8' each; as census tracts 5, 8, and 11 only have access to physician *b*, the ratio for them equals '1/4' each. However, census tract 4 has its centroid located inside the overlay of Catchment Area *a* and Catchment Area *b*. In other words, the centroid of census tract 4 is located inside both Catchment Area *a* and Catchment Area *b*, meaning that population and social groups of census tract 4 have access to both physician *a* and physician *b*, thus enjoying higher level of potential accessibility. Accordingly, the ratio for census tract 4 is '3/8' ('1/8+1/4').

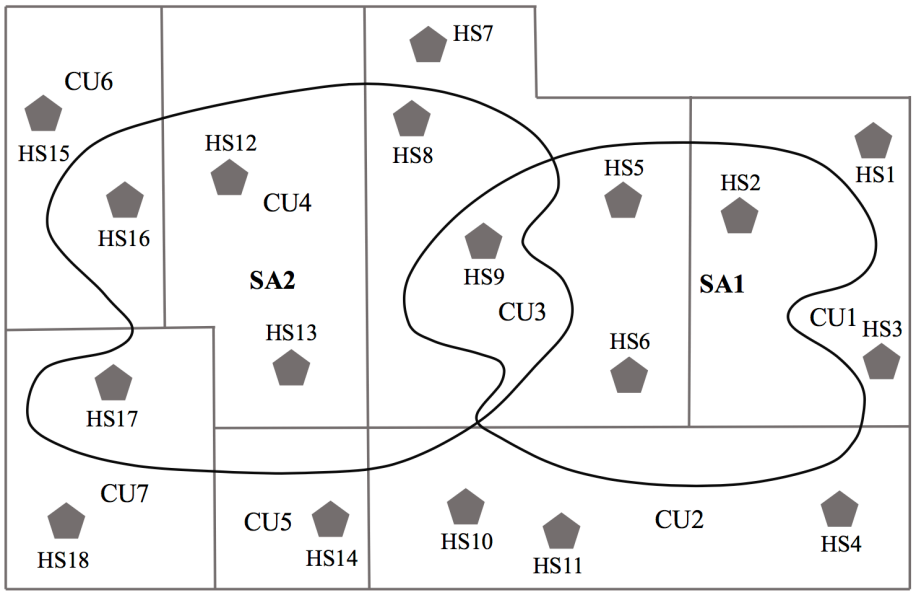
This research adapts from Luo and Wang's (2003) research concerning the way how the census tracts (Output Areas in this research) located inside the overlay of Service Areas are measured differently from those only located inside one Service Area. Conceptual diagrams were created to illustrate how to take into account the overlay of Service Areas when measuring potential accessibility applying the HSW and PWC techniques. The empirical comparison between the percentages of population inside a merged Service Area and inside the same individual Service Areas on the Output Area level will be made choosing two overlaid Service Areas of GP practices in Newcastle as an example after obtaining the results of the calculation in the upcoming sections. The following paragraphs will focus on conceptual illustrations of how to take into account the overlay of Service Areas applying the HSW and PWC techniques.

6.4.1 The Illustration of How to Take into Account the Overlay of Service Areas in Potential Accessibility Measurement Applying the HSW Technique

The illustration of how to take into account the overlay of Service Areas in potential accessibility measurement applying the HSW technique draws upon Luo and Wang's (2003) study on how to take into account the overlay of different Catchment Areas (Service Areas) to calculate the physician-to-population ratios for potential access measurement (See Figure 9).

Figure 10 is a conceptual diagram for the illustration applying the HSW technique. In the diagram, the rectangles in grey represent census units (7 in total), the curved-edge polygons in black represent Service Areas (2 in total) and the pentagons in grey represent Household Spaces (18 in total). To simplify the illustration, one pentagon was counted as one Household Space.

Figure 10 Conceptual Diagram of How to Take into Account the Overlay of Service Areas in Potential Accessibility Measurement Applying the HSW Technique



Source: Own analysis

As the application of the HSW technique starts from calculating weights of Output Areas with access, the illustration of how to take into account the overlay of Service Areas in the calculation of potential accessibility applying the technique will begin with how the weight of Output Area is assigned. As the number of potential accessibility for each Output Area is calculated by multiplying the weight of the Output Area with access by the number of population (residents) and its subgroups (social groups) of the Output Area respectively, the illustration here will begin with how the weights are assigned differently to Output Areas located inside the overlay of Service Areas from Output Areas located inside only one Service Area. It will then focus on the illustration of how to take into account the overlay of Service Areas in the calculation of the number and percentage of potential accessibility applying the HSW technique.

According to how weights are assigned to census units with access applying the HSW technique illustrated in 6.2.1, the weight of '1/3' is assigned to census unit 1 (CU1) as 1 out of the 3 Household Spaces within it is located inside Service Area 1 (see Figure 10). The weight of '0' is assigned to census unit 2 and 5 as all Household Spaces within them (3 and 1 respectively) are located outside either Service Area 1 or 2. The weight of '1' is assigned to census unit 4 as all Household Spaces within it (2) are located inside Service Area 2. The weight of '1/2' is assigned to census unit 6 and 7 each as 1 out of the 2 Household Spaces within them each is located inside Service Area 2. While for census unit 3, it has 1 Household Space (HS9) out of the five (HS5-9) is located inside the

overlay of Service Area 1 and 2. The weight of '3/5' is assigned to census unit 3 as 3 out of 5 Household Spaces within it are located inside Service Area 1, and the weight of '2/5' is assigned to census unit 3 as 2 out of 5 Household Spaces within it are located inside Service Area 2. Thus, two weights of '3/5' and '2/5', i.e. the weight of '1' ('3/5+2/5'), are assigned to census unit 3 applying the HSW technique.

It is worth noting here that if there is at least one Household Space of an Output Area located in the overlay of more than one Service Area, more than one weight will be assigned to the Output Area with access applying the HSW technique. The value of the weight depends on the relationship between the Output Area and Service Areas that it is overlapped with.

As the purpose of calculating the number of social groups with potential accessibility is to calculate the percentage of potential accessibility and then the percentage of potential access so as to assess spatial equity, the percentage of social groups with potential accessibility will be calculated. It is worth noting here that the percentage of potential access is calculated by multiplying the percentage of potential accessibility by size weighting, which will be illustrated in detail later in this chapter.

The reason why using the percentage rather than the number of social groups with potential access to assess spatial equity is that the population sizes of the two related social groups (e.g. the Deprived Household and Non-Deprived Household) are likely to be different in a city. For instance, the total number of the Deprived Household could be larger or smaller than the total number of the Non-Deprived Household in a city. In this case, it is not appropriate to compare the number of the Deprived Household to the number of the Non-Deprived Household with potential access in a city. Instead, it is appropriate to compare the percentage of the Deprived Household with potential access in a city with the percentage of Non-Deprived Households with potential access in the city on the city scale.

To calculate the percentage of potential accessibility on the city scale, it is necessary to identify all Output Areas with Household Spaces located inside Service Areas for both once and multiple times in a city. Thus, it is necessary to calculate the population and total number of each social group that are involved in the calculation of the number of each social group with potential accessibility in the city respectively as the denominators. As shown conceptually in Figure 10 that the Output Areas with no Household Space located inside the overlay of Service Areas have only one weight assigned to them each,

thus population or the number of each social group within those Output Areas is only calculated once when calculating the number of potential accessibility in the city. Accordingly, the population or the total number of each social group of those Output Areas is added up only once as the denominators on the city scale. However, the Output Areas with Household Spaces located inside the overlay of Service Areas have more than one weight assigned to each of them. Thus, the population or the total number of each social group within those Output Areas is calculated for more than once when calculating the number of potential accessibility in the city on the city scale. Accordingly, the total number of residents or each social group within those Output Areas is added up for more than once as the denominator on the city scale.

In practice, to take into account the overlay of Service Areas, the calculation of the number of potential accessibility is done by each Service Area of a city on the city scale (the numerator) rather than by merged Service Areas in the city. This means that all Output Areas with Household Spaces located inside Service Areas (i.e. potential accessibility) identified in ArcGIS are exported to Excel for the calculation of the subtotal of the population and each social group by Service Area. In this way, all Output Areas including those with Household Spaces located inside the overlay of Service Areas that are calculated for more than once are taken into account in the calculation of the numerator on the city scale. The whole calculation process of the population (i.e. the number of residents) and each social group with potential accessibility to all GP practices by Service Area in Newcastle applying the HSW technique can be referred to Appendix D, a screenshot of which can be referred to Figure 11.

As can be seen from Figure 11 that the number of Output Areas with potential accessibility is calculated by Service Area in Newcastle on the city scale (the numerator), which automatically takes into account those Output Areas with Household Spaces located inside the overlay of Service Areas. Because the weights of those Output Areas with access and the number of potential accessibility have been calculated more than once in different Service Areas. For instance, the eight Output Areas with OA codes of E0042579, E0042580, E0042583, E0042609, E00175551, E00175553, E00175558 and E00175561 have been involved twice in the calculations as they are located in the overlay of Service Area 1 and 2 applying the HSW technique.

Figure 11 The Calculation Process of the Number of Residents and each Social Group with Potential Accessibility to All GP Practices by Service Area in Newcastle Applying the HSW Technique

OA Code	No. of Household Space in Overlap	No. of Household Space in OA	Weight of OA with Access	No. of Resident	No. of Resident with Access	No. of Deprived Household	No. of Deprived Household with Access	No. of Non-Deprived Household	No. of Non-Deprived Household with Access	No. of Heavy User Group	No. of Heavy User Group with Access	No. of Light User Group	No. of Light User Group with Access
Service Area 1													
E00042579	180	180	**1.00**	152	**152**	117	**117**	35	**35**	9	**9**	187	**187**
E00042580	265	348	**0.76**	184	**140**	98	**75**	86	**65**	5	**4**	442	**337**
E00042583	20	59	**0.34**	60	**20**	35	**12**	25	**8**	5	**2**	169	**57**
E00042609	136	136	**1.00**	149	**149**	65	**65**	84	**84**	24	**24**	472	**472**
E00042822	99	159	**0.62**	151	**94**	95	**59**	56	**35**	2	**1**	289	**180**
E00042826	127	139	**0.91**	242	**221**	148	**135**	94	**86**	7	**6**	393	**359**
E00042829	8	333	**0.02**	230	**6**	145	**3**	85	**2**	9	**0**	307	**7**
E00175551	32	166	**0.19**	128	**25**	67	**13**	61	**12**	10	**2**	215	**41**
E00175553	163	187	**0.87**	121	**105**	80	**70**	41	**36**	1	**1**	235	**205**
E00175558	108	110	**0.98**	121	**119**	68	**67**	53	**52**	6	**6**	210	**206**
E00175561	166	166	**1.00**	139	**139**	112	**112**	27	**27**	2	**2**	223	**223**
Subtotal 1				1677	**1170**	1030	**728**	647	**442**	80	**57**	3142	**2275**
Service Area 2													
E00042579	180	180	**1.00**	152	**152**	117	**117**	35	**35**	9	**9**	187	**187**
E00042580	224	348	**0.64**	184	**118**	98	**63**	86	**55**	5	**3**	442	**285**
E00042583	59	59	**1.00**	60	**60**	35	**35**	25	**25**	5	**5**	169	**169**
E00042609	20	136	**0.15**	149	**22**	65	**10**	84	**12**	24	**4**	472	**69**
E00042670	28	152	**0.18**	146	**27**	111	**20**	35	**6**	40	**7**	329	**61**
E00042671	89	89	**1.00**	88	**88**	63	**63**	25	**25**	16	**16**	110	**110**
E00042672	47	95	**0.49**	90	**45**	71	**35**	19	**9**	13	**6**	1148	**568**
E00042673	170	177	**0.96**	173	**166**	117	**112**	56	**54**	25	**24**	315	**303**
E00042679	72	115	**0.63**	108	**68**	71	**44**	37	**23**	1	**1**	589	**369**
E00175551	17	166	**0.10**	128	**13**	67	**7**	61	**6**	10	**1**	215	**22**
E00175553	22	187	**0.12**	121	**14**	80	**9**	41	**5**	1	**0**	235	**28**
E00175558	41	110	**0.37**	121	**45**	68	**25**	53	**20**	6	**2**	210	**78**
E00175561	166	166	**1.00**	139	**139**	112	**112**	27	**27**	2	**2**	223	**223**
E00175564	21	74	**0.28**	72	**20**	38	**11**	34	**10**	3	**1**	351	**100**
E00175574	44	44	**1.00**	63	**63**	31	**31**	32	**32**	2	**2**	621	**621**
E00175578	6	60	**0.10**	110	**11**	81	**8**	29	**3**	9	**1**	882	**88**
E00175593	208	251	**0.83**	110	**91**	55	**46**	55	**46**	2	**2**	598	**496**
E00175595	64	64	**1.00**	62	**62**	48	**48**	14	**14**	0	**0**	116	**116**
Subtotal 2				2076	**1205**	1328	**797**	748	**407**	173	**86**	7212	**3891**

Source: Own calculation

However, the calculation of the denominator involves identifying the number of times of those Output Areas with Household Spaces located inside the overlay of Service Areas in a city on the city scale. This can be achieved by comparing the code of the Output Areas involved in the calculation of the number of potential accessibility by Service Area with the code of all Output Areas in a city. After identifying the number of times of those Output Areas with Household Spaces located inside the overlay of Service Areas, those Output Areas with extra number of times of calculation were added to the list of all Output Areas in the city. The whole list of Output Area with the extra number of times of the Output Areas being included can be referred to Appendix E, a screenshot of which can be referred to Figure 12.

As can be seen in Figure 12, the OA Codes without highlight represent Output Areas (Output Areas with OA codes of E00042715 and E00042716) involved in the calculation of the number of potential accessibility in the city on the city scale (the numerator) for only once; the OA Codes in yellow (E00042714), orange (E00042713) and blue

(E00042712) represent Output Areas that are involved in the calculation of the number of the numerator for twice, three or four times applying the HSW technique. In this way, all Output Areas involved in the calculation of the number of potential accessibility are identified in the city. The denominator is then calculated by adding up the total number of residents or each social group of all the Output Areas involved in the calculation of the numerator in the city on the city scale.

Figure 12 Output Areas Involved in the Calculation of the Denominator Taking into Account Overlays of Service Areas in Newcastle Applying HSW Technique

OA Code	Resident	Deprived Household	Non-Deprived Household	Heavy User Group	Light User Group
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042714	266	43	81	52	214
E00042714	266	43	81	52	214
E00042715	292	43	84	43	249
E00042716	288	53	76	33	255

Source: Own calculation

After the calculation of the numerator and denominator applying the HSW technique, the percentages of residents and each social group with potential accessibility in a city are calculated accordingly in the city on the city scale. It is worth noting here that different weights may be assigned to the same Output Area with access as a specific weight is assigned to an Output Area based on the relationship between the Output Area and Service Areas that it is overlapped with. Besides, the total number of Output Areas involved in the calculation of the denominator taking into account the overlay of Service Areas in a city could be more than the total number of Output Areas of the city. Because some Output Areas may be calculated more than once if they have Household Spaces located inside more than one Service Area in a city on the city scale.

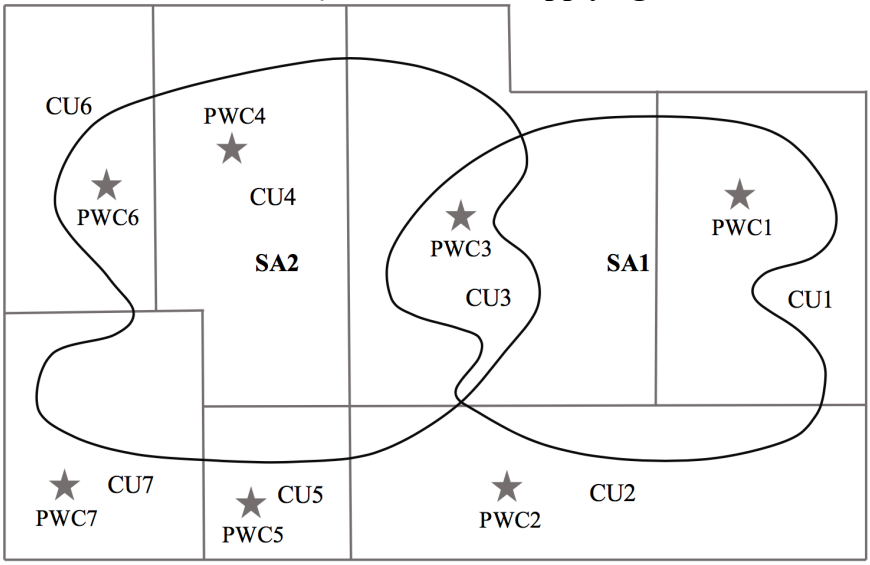
6.4.2 The Illustration of How to Take into Account the Overlay of Service Areas in Potential Accessibility Measurement Applying the PWC Technique

The following paragraph will focus on conceptual illustration of how to take into account the overlay of Service Areas in potential accessibility measurement applying the PWC technique. The illustration of how to take into account the overlay of Service Areas in potential accessibility measurement applying the PWC technique also draws upon Luo

and Wang's (2003) study on how to take into account the overlay of different Catchment Areas (Service Areas) to calculate the physician-to-population ratios for potential access measurement (See Figure 9).

Figure 13 is a conceptual diagram for the illustration applying the PWC technique. In the diagram, the curved-edge polygons in black represent Service Areas (2 in total), the rectangles in grey represent census units (7 in total) and the stars in grey represent population weighted centroids of the census units (7 in total). To simplify the illustration, one pentagon will be counted as one Household Space.

Figure 13 Conceptual Diagram of How to Take into Account the Overlay of Service Areas in Potential Accessibility Measurement Applying the PWC Technique



Source: Own analysis

As the application of the PWC technique begins with identifying population weighted centroids located inside Service Areas and the assigning the weight of '1' or '0' to those Output Areas located inside or outside Service Areas, the illustration will start with identifying and assigning weights to Output Areas here. It will then focus on the illustration of how to take into account the overlay of Service Areas in the calculation of the number and percentage of each social group with potential accessibility applying the PWC technique.

According to how weights are assigned to census units with access applying the PWC technique in 6.2.2, the weight of '1' is assigned to census unit 1 (CU1) as its population weighted centroid is located inside Service Area 1 (see Figure 13). The weight of '1' is assigned to census unit 4 and 6 as their population weighted centroids are located inside Service Area 2. The weight of '0' is assigned to census units 2, 5 and 7 as their

population weighted centroids are located outside either Service Area 1 or 2. While for census unit 3, its population weighted centroid is located in the overlay of Service 1 and 2. The weight of '1' is assigned to it as its population weighted centroid is located in Service Area 1, and the weight of '1' is assigned to it as its population weighted centroid is located Service Area 2. Thus, two weights of '1', i.e. the weight of '2', are assigned to census unit 3 applying the PWC technique.

In calculating the number of each social group with potential accessibility applying the PWC technique, for a census unit located inside only one Service Area (e.g. census units 1, 2, 4, 5, 6 and 7), the number of each social group within each census unit with potential accessibility equals to the total number of each social group within the census unit. For a census unit located inside more than one Service Area (e.g. census unit 3), the number of each social group within each census unit with potential accessibility equals to the sum of the total number of the social group within the census unit multiplying the number of times that the census unit is located inside Service Areas. The number of each social group with potential accessibility in the city on the city scale (the numerator) is then calculated by summing up associated populations.

Similar to what was illustrated for the application of the HSW technique, the denominator on the city scale is calculated before calculating the percentage of potential accessibility applying the PWC technique. As shown conceptually in Figure 13 that the Output Areas with their population weighted centroids located inside only one Service Area have only one weight assigned to them each. Accordingly, the number of residents or each social group of those Output Areas is only calculated once when calculating the number of potential accessibility in the city; the total number of residents or each social group within those Output Areas is added up only once as the denominator on the city scale. However, the Output Areas with their population weighted centroids located inside more than one Service Area have weight of '1' assigned to them for more than once. Accordingly, the number of residents or each social group within those Output Areas is calculated for more than once when calculating the number of potential accessibility in the city; the total number of residents or each social group of all the Output Areas involved in the calculation of the numerator are added up for more than once as the denominator on the city scale.

In practice, to take into account the overlay of Service Areas, the calculation of the number of residents or each social group with potential accessibility is done by each

Service Area of a city on the city scale (the numerator) rather than by merged Service Areas in the city. This means that all Output Areas with their population weighted centroids located inside Service Areas (i.e. potential accessibility) identified in ArcGIS are exported to Excel for the calculation of the subtotal of each social group by Service Area. In this way, all Output Areas including those with their population weighted centroids located inside the overlay of Service Areas calculated for more than once are taken into account in the calculation of the numerator in a city on the city scale. The whole calculation process of the number of residents and each social group with potential accessibility to all GP practices by Service Area in Newcastle applying the PWC technique can be referred to Appendix F, a screenshot of which can be referred to Figure 14.

Figure 14 The Calculation Process of the Number of Residents and Social Groups with Potential Accessibility to All GP Practices by Service Area in Newcastle Applying the PWC Technique

Output Area with Access	No. of Resident	No. of Deprived Household	No. of Non-Deprived Household	No. of Heavy User Group	No. of Light User Group
Service Area 1					
E00042579	152	117	35	9	187
E00042580	184	98	86	5	442
E00042583	60	35	25	5	169
E00042609	149	65	84	24	472
E00042826	242	148	94	7	393
E00175553	121	80	41	1	235
E00175558	121	68	53	6	210
E00175561	139	112	27	2	223
Subtotal 1	1168	723	445	59	2331
Service Area 2					
E00042579	152	117	35	9	187
E00042583	60	35	25	5	169
E00042671	88	63	25	16	110
E00042672	90	71	19	13	1148
E00042673	173	117	56	25	315
E00042679	108	71	37	1	589
E00175561	139	112	27	2	223
E00175574	63	31	32	2	621
E00175595	62	48	14	0	116
Subtotal 2	935	665	270	73	3478

Source: Own calculation

As can be seen from Figure 14 that the number of Output Areas with potential accessibility is calculated by Service Area in Newcastle on the city scale (the numerator), which automatically takes into account those Output Areas with their population weighted centroids located inside the overlay of Service Areas. Because the weights of '1' have been assigned to those Output Areas with their population weighted centroids located inside Service Areas (meaning with access) and the number of potential accessibility have been calculated more than once in different Service Areas. For instance, the three Output Areas with OA codes of E0042579, E0042583 and E00175561

have been involved twice in the calculations as they are located in the overlay of Service Area 1 and 2 applying the PWC technique.

However, the calculation of the denominator involves the identification of the number of times of those Output Areas with population weighted centroids located inside the overlay of Service Areas in a city on the city scale. This can be achieved by comparing the code of the Output Areas involved in the calculation of the number of potential accessibility by Service Area with the code of all Output Areas in a city. The whole list of Output Area with the extra number of times of the Output Areas being included applying the PWC technique can be referred to Appendix G, a screenshot of which can be referred to Figure 15.

Figure 15 Output Areas Involved in the Calculation of the Denominator Taking into Account Overlays of Service Areas in Newcastle Applying the PWC Technique

OA Code	Resident	Deprived Household	Non-Deprived Household	Heavy User Group	Light User Group
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042439	598	86	111	9	589
E00042439	598	86	111	9	589
E00042440	355	46	80	24	331
E00042440	355	46	80	24	331
E00042441	429	75	101	18	411
E00042441	429	75	101	18	411
E00042442	524	46	110	11	513
E00042442	524	46	110	11	513
E00042443	424	64	119	8	416
E00042443	424	64	119	8	416
E00042444	432	54	101	10	422
E00042445	220	43	64	54	166
E00042446	352	44	78	11	341

Source: Own calculation

In Figure 15, the OA Codes without highlight (E00042444, E00042445 and E00042446) represent Output Areas that are involved in the calculation of the number of potential accessibility (the numerator) for only once; the OA Codes in yellow (E00042439, E00042440, E00042441, E00042442 and E00042443) and orange (E00042438) represent Output Areas that are involved in the calculation of the number of the numerator for twice or three times applying the PWC technique. In this way, all Output Areas involved in the calculation of the number of potential accessibility are identified in the city applying the PWC technique. The denominator is then calculated by adding up the total number of residents or each social group involved in the calculation in the city on the city scale.

After calculating the numerator and denominator applying the PWC technique, the percentages of residents and each social group with potential accessibility in a city are calculated for the city on the city scale. It is worth noting here that the total number of Output Areas involved in the calculation of the denominator taking into account the overlay of Service Areas in a city could be more than the total number of Output Areas of the city. Because some Output Areas may be calculated more than once if their population weighted centroids are located inside more than one Service Area in the city on the city scale.

Based on the above illustration of how to take into account the overlay of Service Areas in the calculation of the number and percentage of potential accessibility applying the HSW and PWC techniques, the following two sections will emphasize the illustration of how to apply the two techniques in the context of measuring potential accessibility and potential access to all GP practices in Newcastle on the city scale.

6.5 Potential Accessibility and Potential Access Measurement

To distinguish the application of the two techniques that have been applied originally to make population estimation inside Service Areas, the steps that will be followed in the upcoming two sections to measure potential accessibility and potential access applying the two techniques will be called the HSW and PWC methods rather than HSW and PWC techniques. The application of the HSW method will be illustrated before the PWC method.

6.5.1 The Application of the HSW Method to Measure Potential Accessibility and Potential Access

The HSW method is a population access measurement method for calculating potential accessibility and potential access applying the HSW technique. It calculates the number and percentage of social groups with potential accessibility and potential access to healthcare services based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions).

In this section, three steps will be followed to illustrate how to apply the HSW method to measure potential accessibility and potential access to all GP practices for social groups represented by the four variables, Deprived Household, Non-Deprived Household, Heavy User Group and Light User Group in Newcastle, selected based on the conceptual framework. Besides, the variable Resident (population) will also be calculated for the

purpose of illustrating the implication of involving the overlay of Service Areas in population estimation and potential accessibility measurement later in section 6.7. The following is the three-step illustration of how to calculate the number and percentage of potential accessibility and the percentage of potential access applying the HSW method.

The first step is Service Area Creation - creating individual Service Areas of all the 44 GP practices in Newcastle. The Services Areas are created performing the GIS-based Network Analyst in ArcGIS against the maximum walking distance of half a mile.

The second step is the calculation of weights of Output Areas with access - creating the overlap of the Service Area and the Output Area to calculate the number of Household Spaces (to represent the number of Households) located within the overlap (meaning with access) so as to calculate the weight of each Output Area with access by dividing the number of Household Spaces located inside the overlap by the total number of Household Spaces located inside the Output Area using the following equation.

$$\boldsymbol{W_i} = \frac{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \left\{ \boldsymbol{B_{SA_j}} \cap \boldsymbol{B_{OA_i}} \right\}}{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \boldsymbol{B_{OA_i}}} \qquad \textbf{Equation 3}$$

Where,

$\boldsymbol{W_i}$ = Weight of Output Area *i* with access

$\boldsymbol{N_{HS}}$ = The number of Household Spaces

$\boldsymbol{B_{SA_j}}$ = The boundary of Service Area *j*

$\boldsymbol{B_{OA_i}}$ = The boundary of Output Area *i*

For an Output Area with no Household Space located inside Service Areas, the weight is '0'; for an Output Area with all Household Spaces located inside Service Areas, the weight is '1'; for an Output Area with parts of Household Spaces located inside Service Areas, the weight is '0-1'.

It is worth noting here that there could be one or more than one weights assigned to an Output Area with access. It depends on whether the Output Area is located inside only one Service Area or the overlay of Service Areas on the city scale. If an Output Area is located partially inside multiple overlays of Service Areas, different weights would be assigned to the Output Area for multiple times; if an Output Area is located fully inside multiple overlays of Service Areas, the same weights would be assigned to the Output Area for multiple times.

The third step is potential accessibility and potential access measurement - joining the 2011 Census Data population, deprivation and age datasets representing resident or each social group with the weight dataset in Excel to calculate the number and percentage of residents or each social group with potential accessibility to GP practices using the following equation.

$$\boldsymbol{N_{PAB_c} = \sum_{i=1}^{m} N_{R/SG_j}},\ \boldsymbol{N_{R/SG_j} = \sum_{i=1}^{n}(N_{R/SG_i} W_i)} \qquad \textbf{Equation 4}$$

Where,

$\boldsymbol{N_{PAB_c}}$= The number of Potential Accessibility in a city

$\boldsymbol{N_{R/SG_j}}$ = The number of Residents or each Social Group in Service Area *j*

$\boldsymbol{N_{R/SG_i}}$ = The number of Residents or each Social Group in Output Area *i*

$\boldsymbol{W_i}$ = The weight of Output Area *i* with access

After exporting the joined datasets to Excel, the percentage of potential accessibility will be calculated by dividing the number of residents or each social group with potential accessibility by the total number of residents or each social group involved in the calculation of the number of potential accessibility in the city taking into account the overlay of Service Areas on the city scale using the following equation.

$$\boldsymbol{P_{PAB_c} = \sum_{i=1}^{m} P_{PAB_j}},\ \boldsymbol{P_{PAB_j} = \frac{N_{R/SGPAB_j}}{N_{R/SG_c}}} \qquad \textbf{Equation 5}$$

Where,

$\boldsymbol{P_{PAB_c}}$ = The percentage of Potential Accessibility in a city on the city scale

$\boldsymbol{P_{PAB_j}}$ = The percentage of Potential Accessibility in Service Area *j*

$\boldsymbol{N_{R/SGPAB_j}}$ = The number of Residents or each Social Group with Potential Accessibility in Service Area *j*

$\boldsymbol{N_{R/SG_c}}$ = The total number of Residents or each Social Group involved in the calculation of the number of Potential Accessibility in a city taking into account the overlay of Service Areas

The calculation of the percentage of potential access requires the calculation of the percentage of potential accessibility to GP practices and size weighting (using the number of FTE GPs as an indicator to represent the size of GP practices) of each GP practice. The percentage of potential accessibility for each Service Area is the subtotal of the percentages of potential accessibility of each Output Area. For calculation of the size

weighting followed three steps. First, update the number of FTE GP data in Newcastle based on the General Practice data (September 2016). Second, calculate the total number of the FTE GPs in a city. Third, calculate size weighting for each GP practice by dividing the number of FTE GP of each GP Practice by the total number of the FTE GPs in the city.

The percentage of potential access to all GP practices for each social group is then calculated by multiplying the percentage of potential accessibility to all GP practices by Service Area for each social group by the size weighting of each GP practice in a city using the following equation.

$$\boldsymbol{P_{PA_c} = \sum_{j=1}^{m} P_{PA_j}},\ \boldsymbol{P_{PA_j} = P_{PAB_j}\left(S_{GPP_j}/S_{GPP_c}\right)} \qquad \textbf{Equation 6}$$

Where,

$\boldsymbol{P_{PA_c}}$ = The percentage of Potential Access in a city
$\boldsymbol{P_{PA_j}}$ = The percentage of Potential Access in Service Area *j*
$\boldsymbol{P_{PAB_j}}$ = The percentage of Potential Accessibility in Service Area *j*
$\boldsymbol{S_{GPP_j}}$ = The Size of GP Practice *j*
$\boldsymbol{S_{GPP_c}}$ = The Size of all GP Practices in the city

Based on the illustration above, the following is the process of the application of the HSW method to measure potential accessibility and potential access to all GP practices for the five variables in Newcastle based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). For the first step, individual Service Areas had been created in the previous section, they were adopted in this here.

As to the calculation of weights of Output Areas with access, the overlap of each of the 910 Output Areas and the 44 Service Areas of all GP practices was created. The numbers of Household Spaces located inside the overlap and each of the Output Areas were calculated respectively in ArcGIS. The two datasets were then exported to Excel to calculate the subtotals of Household Spaces located inside the overlaps and the subtotal of Household Spaces located inside the 910 Output Areas to calculate the weight of each Output Area with access to all GP practices in Newcastle using Equation 3.

Concerning the calculation of the number and percentage of potential accessibility to all GP practices for the five variables, the number of potential accessibility was calculated by merging census datasets of the five variables with the weight dataset in Excel to calculate the number of the five variables with potential accessibility to all GP practices in the city

using Equation 4. Taking into account the overlay of Service Areas, there are 987 Output Areas overlapping with Service Areas, which were counted as Output Areas with access (partial or full access) to all GP practices in the city. Census datasets concerning the five variables in the 987 Output Areas were then added up by Service Area for each of the five variables.

Here, the number of Output Areas (987 Output Areas) involved in the calculation exceeds the total number of the Output Areas (910 Output Areas) in Newcastle, as Output Areas with Household Spaces located inside two to four overlaid Service Areas were calculated twice to four times. This means that there are Output Areas with Household Spaces located inside the overlaid Service Areas in Newcastle when applying the HSW method to calculate the number of residents and social groups with potential accessibility to all GP practices in the city on the city scale (the numerator). The results of the number of population and each social group with potential accessibility applying the HSW method are as follows: there are 206,672 residents (population), 50,643 Deprived Households, 34,607 Non-Deprived Households, 24,924 Heavy User Groups and 181,748 Light User Groups with potential accessibility taking into account the overlay of Service Areas in Newcastle on the city scale.

To calculate the percentage of residents and social groups with potential accessibility to all GP practices in the city, the total number of residents and each social group involved in the calculation of the numerator was calculated. Taking into account the 2 to 4 overlaid Service Areas, the number of times of Output Areas with Household Spaces located inside Service Areas were identified by comparing the OA Codes of Output Areas with potential accessibility and the OA Codes of the 910 Output Areas in Newcastle. The Output Areas with extra number of times of calculation were added to the list of the 910 Output Areas joined with the census data of the five variables in the city. This enables the identification of all Output Areas involved in the calculation of potential accessibility in the city on the city scale, which is used to calculate the denominator by adding up the total number of residents or each social group involved in the calculation of the numerator on the city scale.

In total, there are 1,282 Output Areas involved in the calculation of the numerator. The number of Output Areas involved in the calculation here (1282) is more than the 910 Output Areas in the city. This means that there are Output Areas with Household Spaces located inside different Service Areas in Newcastle for more than once when calculating

the denominator applying the HSW method on the city scale. The results of the calculation of the denominators applying the HSW method are as follows: in total, there are 405,105 residents, 97,670 Deprived Households, 69,296 Non-Deprived Households, 50,667 Heavy User Groups and 354,514 Light User Groups involved in the calculation of the number of residents and social groups within Output Areas with Household Spaces located inside Service Areas in Newcastle taking into account the overlay of Service Areas in the city on the city scale.

Accordingly, the percentages of residents and each social group with potential accessibility to all GP practices in the city on the city scale were calculated by dividing the numerators by the denominators of the five variables respectively calculated above applying the HSW method. The result can be referred to Table 10.

Table 10 The Number and Percentage of Residents and Social Groups with Potential Accessibility to All GP Practices in Newcaslte Taking nto Account the Overlay of Service Areas Applying the HSW Method on the City Scale

Variable	No. of Potential Accessibility	Total Number (1282 OAs)	% of Potential Accessibility
Resident	206,672	405,105	51.02
Deprived Household	50,643	97,670	51.85
Non-Deprived Household	34,607	69,296	49.94
Heavy User Group	24,924	50,667	49.19
Light User Group	181,748	354,514	51.27

Source: Own calculation

In order to calculate the percentage of social groups with potential access to all GP practices in Newcastle applying the HSW method, the percentage of potential accessibility to all GP practices in the city by Service Area and the size weighting for each of the 44 GP practices were calculated based on the calculations in the previous steps. The calculation of the percentage of potential accessibility for the Deprived and Non-Deprived Households will be taken as examples for illustration purposes.

For calculating the percentages of the Deprived and Non-Deprived Households with potential accessibility, the numbers of the Deprived and Non-Deprived Households with potential accessibility to all the GP practices in Newcastle were calculated separately for each of the 44 Output Areas; which were then divided by the total number of the Deprived Household (97,670) and Non-Deprived Household (69,296) in the city taking into account the overlay of Service Areas (1282 Output Areas in total) calculated in the previous steps (see Table 10). The process of the calculation and the result of the

percentage of the Deprived and Non-Deprived Households with potential accessibility for each of the 44 Service Areas can be referred to Table 11. The calculations of the rest two variables, Heavy User Group and Light User Groups followed the same process.

Table 11 The Calculation of the Percentage of Potential Accessibility Applying the HSW Method in Newcastle by Service Area Taking into Account the Overlays of Service Areas

Service Area (SA) of each GP Practice (GPP)	No. of Deprived Household with Potential Accessibility	Total Number of Deprived Household (1282 OAs)	% of Deprived Household with Potential Accessibility	No. of Non-Deprived Household with Potential Accessibility	Total Number of Non-Deprived Household (1282 OAs)	% of Non-Deprived Household Potential Accessibility
SA of GPP 1	728	97670	0.7451	442	69296	0.6383
SA of GPP 2	797	97670	0.8161	407	69296	0.5880
SA of GPP 3	566	97670	0.5791	137	69296	0.1979
SA of GPP 4	778	97670	0.7971	213	69296	0.3078
SA of GPP 5	1002	97670	1.0257	642	69296	0.9258
SA of GPP 6	529	97670	0.5413	322	69296	0.4647
SA of GPP 7	950	97670	0.9723	439	69296	0.6337
SA of GPP 8	1808	97670	1.8516	1130	69296	1.6313
SA of GPP 9	1201	97670	1.2297	1939	69296	2.7977
SA of GPP 10	1235	97670	1.2644	1994	69296	2.8770
SA of GPP 11	913	97670	0.9351	1805	69296	2.6051
SA of GPP 12	562	97670	0.5756	918	69296	1.3247
SA of GPP 13	515	97670	0.5277	1155	69296	1.6663
SA of GPP 14	628	97670	0.6432	1337	69296	1.9301
SA of GPP 15	938	97670	0.9604	1597	69296	2.3047
SA of GPP 16	326	97670	0.3336	368	69296	0.5316
SA of GPP 17	326	97670	0.3336	368	69296	0.5316
SA of GPP 18	1122	97670	1.1492	414	69296	0.5973
SA of GPP 19	1200	97670	1.2288	641	69296	0.9253
SA of GPP 20	822	97670	0.8416	849	69296	1.2255
SA of GPP 21	361	97670	0.3700	540	69296	0.7795
SA of GPP 22	2277	97670	2.3317	646	69296	0.9328
SA of GPP 23	1145	97670	1.1721	362	69296	0.5221
SA of GPP 24	1648	97670	1.6871	388	69296	0.5599
SA of GPP 25	2281	97670	2.3352	1225	69296	1.7674
SA of GPP 26	1791	97670	1.8332	519	69296	0.7487
SA of GPP 27	1801	97670	1.8437	889	69296	1.2824
SA of GPP 28	1644	97670	1.6835	1014	69296	1.4627
SA of GPP 29	1073	97670	1.0985	794	69296	1.1460
SA of GPP 30	1053	97670	1.0777	779	69296	1.1244
SA of GPP 31	852	97670	0.8719	433	69296	0.6256
SA of GPP 32	1257	97670	1.2867	544	69296	0.7853
SA of GPP 33	1215	97670	1.2439	658	69296	0.9492
SA of GPP 34	1278	97670	1.3084	593	69296	0.8562
SA of GPP 35	1312	97670	1.3434	543	69296	0.7843
SA of GPP 36	1332	97670	1.3636	494	69296	0.7132
SA of GPP 37	1864	97670	1.9088	1142	69296	1.6483
SA of GPP 38	1972	97670	2.0190	1115	69296	1.6097
SA of GPP 39	1943	97670	1.9892	1104	69296	1.5936
SA of GPP 40	1789	97670	1.8317	522	69296	0.7530

SA of GPP 41	1344	97670	1.3760	434	69296	0.6257
SA of GPP 42	723	97670	0.7403	450	69296	0.6500
SA of GPP 43	1227	97670	1.2559	1838	69296	2.6525
SA of GPP 44	516	97670	0.5288	460	69296	0.6643

Source: Own calculation

The size weighting for each of the 44 GP practices was calculated by dividing the number of FTE GPs of each GP Practice by the total number of the FTE GPs in the city. The calculation process and the result of the size weighting of each of the 44 GP practices (in bald) can be referred to Table 12.

Table 12 The Calculation of Size Weighting for the 44 GP Practices in Newcastle

Service Area (SA) of each GP Practice (GPP)	No. of FTE GP in each GPP	Total No. of FTE GP in Newcastle	Size Weighting of each GPP
SA of GPP 1	2.48	156.68	**0.0158**
SA of GPP 2	6.84	156.68	**0.0437**
SA of GPP 3	0.75	156.68	**0.0048**
SA of GPP 4	1.94	156.68	**0.0124**
SA of GPP 5	1.92	156.68	**0.0123**
SA of GPP 6	2.77	156.68	**0.0177**
SA of GPP 7	5.71	156.68	**0.0364**
SA of GPP 8	2.65	156.68	**0.0169**
SA of GPP 9	1.5	156.68	**0.0096**
SA of GPP 10	4.56	156.68	**0.0291**
SA of GPP 11	5.26	156.68	**0.0336**
SA of GPP 12	2.16	156.68	**0.0138**
SA of GPP 13	4.4	156.68	**0.0281**
SA of GPP 14	4.6	156.68	**0.0294**
SA of GPP 15	5.53	156.68	**0.0353**
SA of GPP 16	3.11	156.68	**0.0198**
SA of GPP 17	3.11	156.68	**0.0198**
SA of GPP 18	2.25	156.68	**0.0144**
SA of GPP 19	1.94	156.68	**0.0124**
SA of GPP 20	1.6	156.68	**0.0102**
SA of GPP 21	3.4	156.68	**0.0217**
SA of GPP 22	2.81	156.68	**0.0179**
SA of GPP 23	0.75	156.68	**0.0048**
SA of GPP 24	2.25	156.68	**0.0144**
SA of GPP 25	8.33	156.68	**0.0532**
SA of GPP 26	2.3	156.68	**0.0147**
SA of GPP 27	6.66	156.68	**0.0425**
SA of GPP 28	4.17	156.68	**0.0266**
SA of GPP 29	2.3	156.68	**0.0147**
SA of GPP 30	6.14	156.68	**0.0392**
SA of GPP 31	1.92	156.68	**0.0123**
SA of GPP 32	4.01	156.68	**0.0256**
SA of GPP 33	4.6	156.68	**0.0294**
SA of GPP 34	0.55	156.68	**0.0035**
SA of GPP 35	1.92	156.68	**0.0123**
SA of GPP 36	6.84	156.68	**0.0437**
SA of GPP 37	4.16	156.68	**0.0266**
SA of GPP 38	1.76	156.68	**0.0112**
SA of GPP 39	2.65	156.68	**0.0169**

SA of GPP 40	6.82	156.68	**0.0435**
SA of GPP 41	8.05	156.68	**0.0514**
SA of GPP 42	1.76	156.68	**0.0112**
SA of GPP 43	4.78	156.68	**0.0305**
SA of GPP 44	2.67	156.68	**0.0170**

Source: Own calculation

After that, the percentages of social groups with potential access to all GP practices in Newcastle by Service Area were calculated by multiplying the percentage of social groups with potential accessibility to all GP practices by Service Area by the size weighting of each GP practice in a city using Equation 6. The process of the calculation and the results of potential access for each of the 44 Service Areas (in bold) can be referred to Table 13.

Table 13 The Calculation of the Percentage of Potential Access Applying the HSW Method in Newcastle by Service Area Taking into Account the Overlay of Service Areas

Service Area (SA) of each GP Practice (GPP)	Size Weighting of each GPP	% of Deprived Household with Potential Accessibility	% of Deprived Household with Potential Access	% of Non-Deprived Household Potential Accessibility	% of Non-Deprived Household Potential Access	% of Heavy User Group with Potential Accessibility	% of Heavy User Group with Potential Access	% of Light User Group with Potential Accessibility	% of Light User Group with Potential Access
SA of GPP 1	0.0158	0.7451	**0.0118**	0.6383	**0.0101**	0.1126	**0.0018**	0.6416	**0.0102**
SA of GPP 2	0.0437	0.8161	**0.0356**	0.5880	**0.0257**	0.1697	**0.0074**	1.0976	**0.0479**
SA of GPP 3	0.0048	0.5791	**0.0028**	0.1979	**0.0009**	0.5203	**0.0025**	0.3974	**0.0019**
SA of GPP 4	0.0124	0.7971	**0.0099**	0.3078	**0.0038**	0.7636	**0.0095**	0.5229	**0.0065**
SA of GPP 5	0.0123	1.0257	**0.0126**	0.9258	**0.0113**	0.9884	**0.0121**	0.9416	**0.0115**
SA of GPP 6	0.0177	0.5413	**0.0096**	0.4647	**0.0082**	0.5161	**0.0091**	0.4184	**0.0074**
SA of GPP 7	0.0364	0.9723	**0.0354**	0.6337	**0.0231**	0.9974	**0.0363**	0.7152	**0.0261**
SA of GPP 8	0.0169	1.8516	**0.0313**	1.6313	**0.0276**	0.9238	**0.0156**	2.1836	**0.0369**
SA of GPP 9	0.0096	1.229	**0.0118**	2.7977	**0.0268**	0.9628	**0.0092**	2.3362	**0.0224**
SA of GPP 10	0.0291	1.2644	**0.0368**	2.8770	**0.0837**	1.0363	**0.0302**	2.3678	**0.0689**
SA of GPP 11	0.0336	0.9351	**0.0314**	2.6051	**0.0875**	0.8089	**0.0272**	2.0559	**0.0690**
SA of GPP 12	0.0138	0.5756	**0.0079**	1.3247	**0.0183**	0.9502	**0.0131**	0.8022	**0.0111**
SA of GPP 13	0.0281	0.5277	**0.0148**	1.6663	**0.0468**	1.1477	**0.0322**	0.9897	**0.0278**
SA of GPP 14	0.0294	0.6432	**0.0189**	1.9301	**0.0567**	1.3730	**0.0403**	1.1477	**0.0337**
SA of GPP 15	0.0353	0.9604	**0.0339**	2.3047	**0.0813**	1.6352	**0.0577**	1.3967	**0.0493**
SA of GPP 16	0.0198	0.3336	**0.0066**	0.5316	**0.0106**	0.3988	**0.0079**	0.4182	**0.0083**

SA of GPP 17	0.0198	0.3336	**0.0066**	0.5316	**0.0106**	0.3988	**0.0079**	0.4182	**0.0083**
SA of GPP 18	0.0144	1.1492	**0.0165**	0.5973	**0.0086**	0.8934	**0.0128**	0.8724	**0.0125**
SA of GPP 19	0.0124	1.2288	**0.0152**	0.9253	**0.0115**	1.1611	**0.0144**	1.0865	**0.0135**
SA of GPP 20	0.0102	0.8416	**0.0086**	1.2255	**0.0125**	1.1167	**0.0114**	0.8932	**0.0091**
SA of GPP 21	0.0217	0.3700	**0.0080**	0.7795	**0.0169**	0.9051	**0.0196**	0.5038	**0.0109**
SA of GPP 22	0.0179	2.3317	**0.0418**	0.9328	**0.0167**	1.0864	**0.0195**	1.3162	**0.0236**
SA of GPP 23	0.0048	1.1721	**0.0056**	0.5221	**0.0025**	1.1984	**0.0057**	1.0951	**0.0052**
SA of GPP 24	0.0144	1.6871	**0.0242**	0.5599	**0.0080**	1.0257	**0.0147**	1.0492	**0.0151**
SA of GPP 25	0.0532	2.3352	**0.1242**	1.7674	**0.0940**	2.8814	**0.1532**	2.7250	**0.1449**
SA of GPP 26	0.0147	1.8332	**0.0269**	0.7487	**0.0110**	1.6263	**0.0239**	1.2869	**0.0189**
SA of GPP 27	0.0425	1.8437	**0.0784**	1.2824	**0.0545**	2.2067	**0.0938**	1.9016	**0.0808**
SA of GPP 28	0.0266	1.6835	**0.0448**	1.4627	**0.0389**	1.8635	**0.0496**	1.6159	**0.0430**
SA of GPP 29	0.0147	1.0985	**0.0161**	1.1460	**0.0168**	1.5477	**0.0227**	0.9239	**0.0136**
SA of GPP 30	0.0392	1.0777	**0.0422**	1.1244	**0.0441**	1.5174	**0.0595**	0.9057	**0.0355**
SA of GPP 31	0.0123	0.8719	**0.0107**	0.6256	**0.0077**	0.9731	**0.0119**	0.6940	**0.0085**
SA of GPP 32	0.0256	1.2867	**0.0329**	0.7853	**0.0201**	1.3381	**0.0342**	0.9030	**0.0231**
SA of GPP 33	0.0294	1.2439	**0.0365**	0.9492	**0.0279**	1.2119	**0.0356**	0.9768	**0.0287**
SA of GPP 34	0.0035	1.3084	**0.0046**	0.8562	**0.0030**	1.3536	**0.0048**	1.0881	**0.0038**
SA of GPP 35	0.0123	1.3434	**0.0165**	0.7843	**0.0096**	1.3493	**0.0165**	1.1702	**0.0143**
SA of GPP 36	0.0437	1.3636	**0.0595**	0.7132	**0.0311**	1.3968	**0.0610**	1.0022	**0.0437**
SA of GPP 37	0.0266	1.9088	**0.0507**	1.6483	**0.0438**	1.1490	**0.0305**	1.6737	**0.0444**
SA of GPP 38	0.0112	2.0190	**0.0227**	1.6097	**0.0181**	1.2033	**0.0135**	1.7575	**0.0197**
SA of GPP 39	0.0169	1.9892	**0.0336**	1.5936	**0.0270**	1.1883	**0.0201**	1.7369	**0.0294**

SA of GPP 40	0.0435	1.8317	**0.0797**	0.7530	**0.0328**	1.5869	**0.0691**	1.2665	**0.0551**
SA of GPP 41	0.0514	1.3760	**0.0707**	0.6257	**0.0321**	1.1789	**0.0606**	0.8529	**0.0438**
SA of GPP 42	0.0112	0.7403	**0.0083**	0.6500	**0.0073**	0.7154	**0.0080**	0.6356	**0.0071**
SA of GPP 43	0.0305	1.2559	**0.0383**	2.6525	**0.0809**	1.1685	**0.0356**	1.8867	**0.0576**
SA of GPP 44	0.0170	0.5288	**0.0090**	0.6643	**0.0113**	0.6455	**0.0110**	0.5963	**0.0102**

Source: Own calculation

Based on the above calculations, the percentage of each social group with potential access to all GP practices in Newcastle on the city scale was calculated by summing up the percentage of each social group with potential access of all the 44 Service Areas of GP practices in the city applying the HSW method. The result can be referred to Table 14.

Table 14 The Perentage of Social Groups with Potential Access to All GP Practices in Newcaslte on the City Scale Applying the HSW Method

Conception Assessed	Variable	% of Potential access
Need	Deprived Household	1.2441
	Non-Deprived Household	1.2216
Demand	Heavy User Group	1.2334
	Light User Group	1.2633

Source: Own calculation

6.5.2 The Application of the PWC Method to Measure Potential Accessibility and Potential Access

The PWC method is a place access measurement method for calculating potential accessibility and potential access applying the PWC technique. It calculates the number and percentage of social groups with potential accessibility and potential access to healthcare services based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). In this section, the application of the PWC method will be illustrated to measure potential accessibility and potential access to all GP practices for the four variables representing social groups, i.e. Deprived Household, Non-Deprived Household, Heavy User Group and Light User Group, in Newcastle on the city scale selected based on the conceptual framework. The following is the three-step illustration.

The first step is Service Area Creation. This is the same as in the application of the HSW method. ***The second step is the application of the Have Their Centre In criterion to identify population weighted centroids inside the individual Service Areas***. This is achieved by clipping the 2011 population weighted centroids for each Service Area in the city and selecting the Output Areas with population weighted centroids located inside the Service Areas to be counted as with potential accessibility by Service Area.

The third step is potential accessibility and potential access measurement. In this step, the 2011 Census Datasets of each social group are joined with the population weighted centroid dataset in ArcGIS. The joined datasets are then exported to Excel to calculate the number of each social group with potential accessibility to all GP practices in Newcastle by Service Area taking into account the overlay of Service Areas. After that, the number

of potential accessibility is obtained by adding up the results of each Service Area in the city. The percentage of potential accessibility is calculated by dividing the number of each social group with potential accessibility in the city (the numerator) on the city scale by the total number of each social group involved in the calculation of the numerator (the denominator) in the city taking into account the overlay of Service Areas.

The percentage of potential access is then calculated based on the percentage of potential accessibility by Service Area integrating the size of healthcare services using the number of FTE GPs (size weighting) to represent the size of GP practices. The process of calculating the percentage of potential access applying the PWC method is the same as the application of the HSW method. The only difference is that it is calculated based on the percentage of potential accessibility calculated applying the PWC method.

Based on the illustration above, the following is the process of the application of the PWC method to measure potential accessibility and potential access to all GP practices for each social group in Newcastle on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). First, the 44 individual Service Areas in Newcastle created earlier in ArcGIS were adopted here for the calculations applying the PWC method. Second, the population weighted centroids of the 910 Output Areas of Newcastle were clipped by the 44 Service Areas. According to the Attribute Table, taking into account the overlay of Service Areas (2 or 3 overlaid Service Areas in this case), there are 643 Output Areas with population weighted centroids located inside Service Areas, which were counted as Output Areas with access to all GP practices in the city on the city scale. The dataset of the 643 Output Areas by Service Area was then exported to Excel for further calculation.

Third, the number of each social group of the 643 Output Areas located inside the 44 Service Areas was added up to obtain the subtotal of social groups with potential accessibility by Service Area, and then further added up to obtain the total number of each social group with potential accessibility to all GP practices in the city. To illustrate the process, the calculation of the Deprived Household was taken as an example. The data of the Deprived Household was joined with the data of the 643 Output Areas with related census datasets by the 44 Service Areas in ArcGIS, which was then exported from the Attribute Table of ArcGIS to Excel.

In Excel, the number of the Deprived Household in the 643 Output Areas was added up by the 44 Service Areas to obtain the subtotal of the Deprived Household with access to

all GP practices by Service Area to calculate the total number of the Deprived Household with potential accessibility in Newcastle. The results of the number of each social group with potential accessibility applying the PWC method are as follows: there are 50,442 Deprived Households, 34,732 Non-Deprived Households, 25,453 Heavy User Groups and 183,678 Light User Groups with potential accessibility to all GP practices in the city taking into account the overlay of Service Areas on the city scale. It is worth noting here that by calculating the number of social groups by Service Area, it is automatically calculate the number of social groups within Output Areas for two or three times with their population weighted centroids located inside the overlay of two or three different Service Areas.

To calculate the percentage of social groups with potential accessibility to all GP practices in Newcastle, the total number of each social group involved in the calculation of the number of potential accessibility to all GP practices in the city (the denominator) on the city scale was calculated. Again, taking into account the overlay of Service Areas (2 or 3 overlaid Service Areas), the number of times of Output Areas located inside Service Areas was identified by comparing the OA Code of Output Areas with their population weighted centroids located inside Service Areas with the OA Codes of the 910 Output Areas of Newcastle joined with the census data of the four variables. Those Output Areas with extra number of times of calculation were then added to the list of the 910 Output Areas joined with the census data of the city. This enables the identification of all Output Areas involved in the calculation of the numerator taking into account the overlay of Service Areas to calculate the denominator by adding up the total number of each social group involved in the calculation of the numerator on the city scale.

In total, there are 1078 Output Areas involved in the calculation of the numerator in the city taking into account the overlay of Service Areas. The number of the Output Areas here (1078) exceeds the total number of Output Areas (910) in the city. This means that some Output Areas with their population weighted centroids located inside Service Areas in Newcastle for more than once when calculating the total number of social groups involved in the calculation of the numerator on the city scale applying the PWC method. The results are as follows: in total, there are 82,440 Deprived Households, 57,932 Non-Deprived Households, 42,397 Heavy User Groups and 296,397 Light User Groups involved in the calculation of the numerator applying the PWC method in Newcastle taking into account the overlay of Service Areas on the city scale.

Accordingly, the percentages of each social group with potential accessibility to all GP practices applying the PWC method in Newcastle on the city scale were calculated by dividing the numerator by the denominator. The result can be referred to Table 15.

Table 15 The Number and Percentage of Social Groups with Potential Accessibility to All GP Practices in Newcaslte Applying the PWC Method on the City Scale

Conception	Variable	No. of Potential Accessibility	Total Number (1078 OAs)	% of Potential Accessibility
Need	Deprived Household	50,442	82,440	61.19
	Non-Deprived Household	34,732	57,932	59.95
Demand	Heavy User Group	25,453	42,397	60.03
	Light User Group	183,678	296,397	61.97

Source: Own calculation

For the calculation of the percentage of social groups with potential access to all GP practices in Newcastle applying the PWC method, the percentage of each social group with potential accessibility to all GP practices in Newcastle by Service Area was multiplied by the size weighting of each GP practice using Equation 6. The process was the same as illustrated in the previous section for the application of the HSW method. The result of the calculation can be referred to Table 16.

Table 16 The Percentage of Potential Access Applying the PWC Method in Newcastle by Service Area Taking into Account the Overlay of Service Areas

Service Area (SA) of each GP Practice (GPP)	% of Deprived Household with Potential Access	% of Non-Deprived Household Potential Access	% of Heavy User Group with Potential Access	% of Light User Group with Potential Access
SA of GPP 1	0.0139	0.0122	0.0022	0.0124
SA of GPP 2	0.0352	0.0203	0.0075	0.0512
SA of GPP 3	0.0032	0.0012	0.0029	0.0023
SA of GPP 4	0.0125	0.0049	0.0121	0.0085
SA of GPP 5	0.0149	0.0151	0.0145	0.0145
SA of GPP 6	0.0121	0.0109	0.0116	0.0098
SA of GPP 7	0.0477	0.0308	0.0494	0.0357
SA of GPP 8	0.0378	0.0338	0.0186	0.0459
SA of GPP 9	0.0146	0.0335	0.0116	0.0280
SA of GPP 10	0.0446	0.1022	0.0356	0.0846
SA of GPP 11	0.0351	0.1014	0.0276	0.0799
SA of GPP 12	0.0068	0.0163	0.0114	0.0097
SA of GPP 13	0.0216	0.0653	0.0450	0.0393
SA of GPP 14	0.0193	0.0640	0.0431	0.0376
SA of GPP 15	0.0451	0.1037	0.0751	0.0632
SA of GPP 16	0.0083	0.0138	0.0100	0.0107
SA of GPP 17	0.0323	0.0223	0.0333	0.0246

SA of GPP 18	0.0198	0.0102	0.0154	0.0151
SA of GPP 19	0.0208	0.0159	0.0195	0.0185
SA of GPP 20	0.0102	0.0147	0.0129	0.0108
SA of GPP 21	0.0104	0.0218	0.0255	0.0140
SA of GPP 22	0.0227	0.0183	0.0215	0.0261
SA of GPP 23	0.0069	0.0030	0.0070	0.0062
SA of GPP 24	0.0275	0.0083	0.0160	0.0169
SA of GPP 25	0.1454	0.1153	0.1855	0.1742
SA of GPP 26	0.0314	0.0130	0.0282	0.0224
SA of GPP 27	0.0988	0.0643	0.1114	0.0992
SA of GPP 28	0.0548	0.0496	0.0602	0.0558
SA of GPP 29	0.0198	0.0202	0.0283	0.0164
SA of GPP 30	0.0495	0.0514	0.0709	0.0413
SA of GPP 31	0.0107	0.0078	0.0138	0.0087
SA of GPP 32	0.0452	0.0288	0.0481	0.0322
SA of GPP 33	0.0466	0.0354	0.0449	0.0366
SA of GPP 34	0.0056	0.0035	0.0057	0.0046
SA of GPP 35	0.0192	0.0113	0.0199	0.0168
SA of GPP 36	0.0700	0.0374	0.0744	0.0525
SA of GPP 37	0.0619	0.0530	0.0363	0.0532
SA of GPP 38	0.0246	0.0206	0.0155	0.0226
SA of GPP 39	0.0377	0.0300	0.0246	0.0333
SA of GPP 40	0.0940	0.0379	0.0823	0.0647
SA of GPP 41	0.0720	0.0318	0.0591	0.0427
SA of GPP 42	0.0086	0.0075	0.0086	0.0073
SA of GPP 43	0.0420	0.0913	0.0410	0.0627
SA of GPP 44	0.0092	0.0109	0.0111	0.0094

Source: Own calculation

Based on the above calculations, the percentage of each social group with potential access to all GP practices in Newcastle on the city scale was calculated by adding up the percentage of each social group with potential access of all the 44 Service Areas of GP practices in the city applying the PWC method. The result can be referred to Table 17.

Table 17 The Percentage of Social Groups with Potential access to All GP Practices in Newcaslte Applying the PWC Method on the City Scale

Conception	Variable	% of Potential access
Need	Deprived Household	1.4705
	Non-Deprived Household	1.4646
Demand	Heavy User Group	1.4993
	Light User Group	1.5224

Source: Own calculation

6.6 Comparisons between the Results of Potential Accessibility and Potential Access Measurement Applying the HSW and PWC Methods

In this section, the results from the application of the HSW and PWC methods will be compared. The focus will be placed on comparing the results of the numbers and

percentages of social groups with potential accessibility and potential access to all GP practices in Newcastle on the city scale between the application of the two methods.

For comparing the number and percentage of social groups with potential accessibility to all GP practices in Newcastle applying the two methods, a comparison table (Table 18) was created based on the results of the calculations in the previous sections. As can be seen from Table 18 that the difference in the number of each social group with potential accessibility to all GP practices in Newcastle on the city scale is small. This means that even though there are overestimations and underestimations of the populations inside Service Areas when applying the PWC technique, they are evened out when the scale of analysis is the whole city rather than the Service Area within the city.

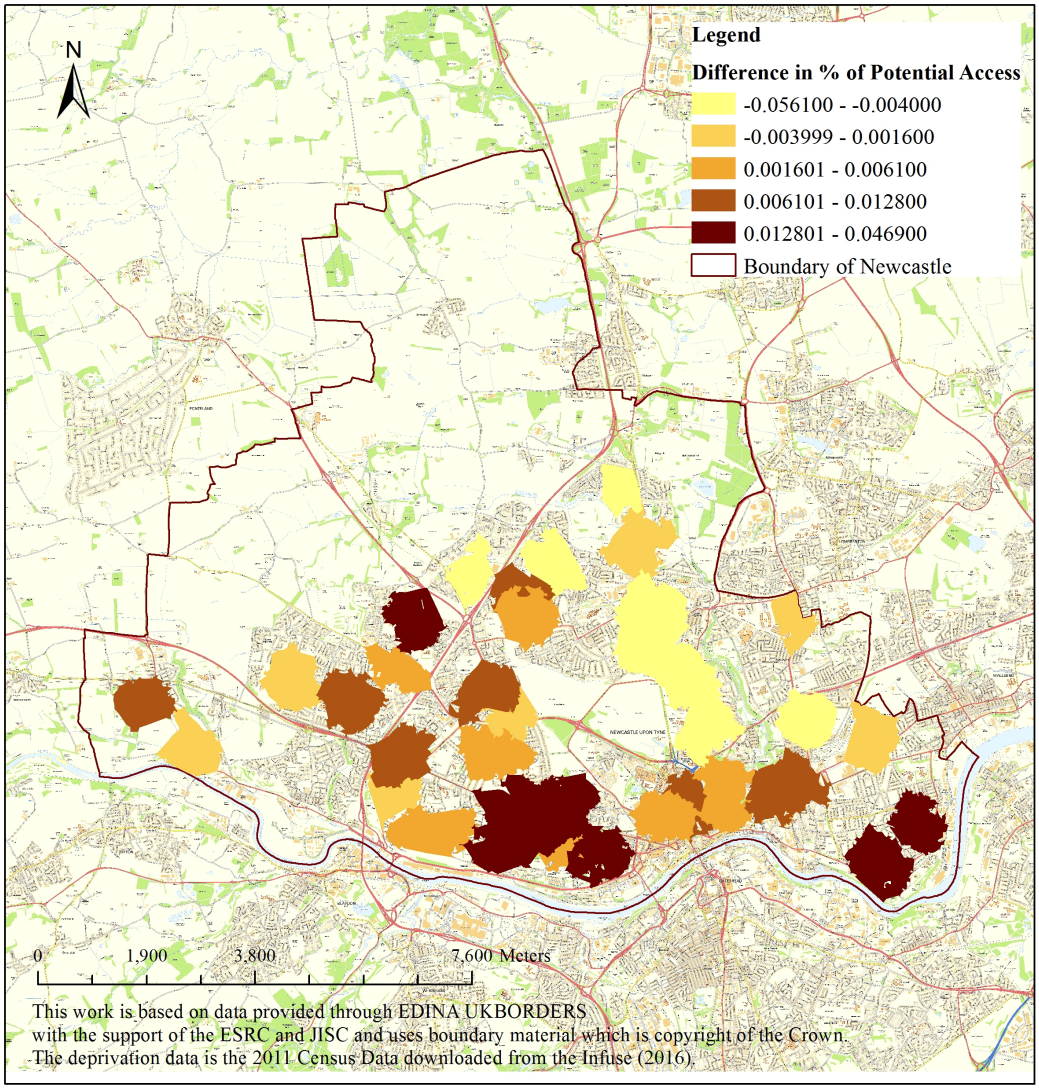
Table 18 The Number and Percentage of Social Groups with Potential Accessibility to All GP Practices in Newcaslte Applying the HSW and PWC Methods

Conception	Variable	Technique	No. of Potential Accessibility	Total Number	% of Potential Accessibility
Equality* and *Need	Deprived Household	HSW	50,643	97,670	51.85
		PWC	50,442	82,440	61.19
	Non-Deprived Household	HSW	34,607	69,296	49.94
		PWC	34,732	57,932	59.95
Equality* and *Demand	Heavy User Group	HSW	34,607	50,677	49.19
		PWC	25,453	42,397	60.03
	Light User Group	HSW	181,748	354,514	51.27
		PWC	183,678	296,397	61.97

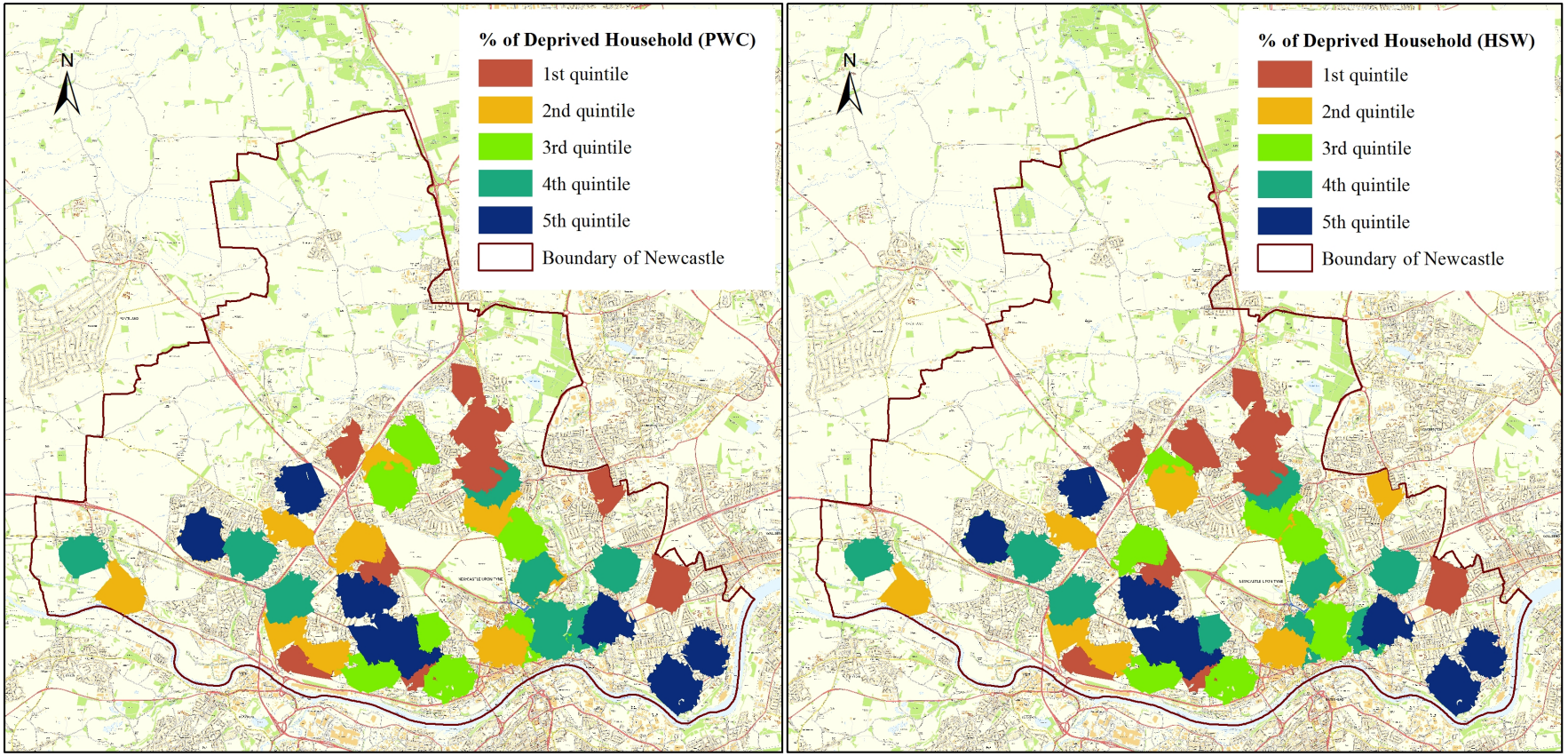
Source: Own calculation

However, there are differences in the percentages of social groups with potential access to all GP practices in Newcastle at the Service Area scale between the application of the two methods. Map 13 shows such difference. The darker the color the larger difference between the percentages. As the percentages were calculated at the Service Area level on the city scale, their values are relatively small and do not indicate the distribution of the difference in the percentages. Thus, a comparative map (Map 14) using quantile was produced to visualize the distribution of the difference taking the Deprived Household as an example. The use of quintiles in the classification of the legend draws upon Fransen et al.'s (2015) approach on comparing the spatial distribution of the accessibility to daycare centers between the application of the 2SFCA (two-step floating catchment area) and CB2SFCA (commuter-based version of the 2SFCA) methods.

Map 13 The Difference in the Percentages of the Deprived and Non-Deprived Households with Potential Access to All GP Practices by Service Area in Newcastle on the City Scale



Map 14 The Distribution of the Difference in the Percentages of the Deprived Household with Potential Access to All GP Practices in Newcastle between the Application of the PWC and HSW Techniques at the Service Area Scale

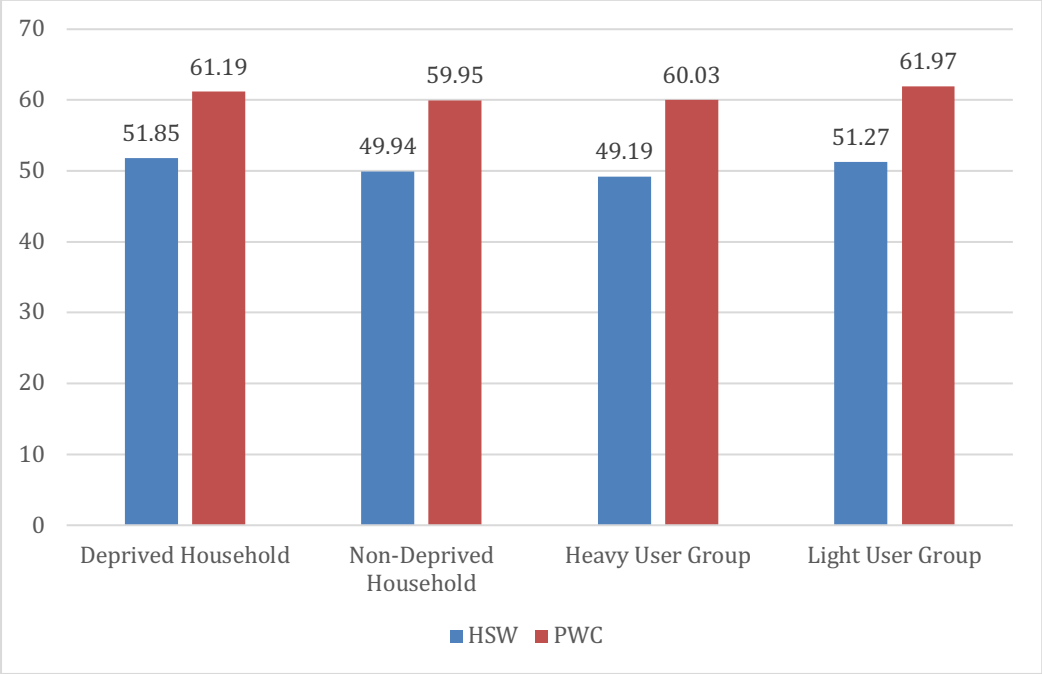


This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
Service Areas are created against half a mile walking distance from GP practices.
The deprivation data is the 2011 Census Data downloaded from the Infuse (2016).

As can be seen from Map 14, except for the highest percentage (i.e. the 5th quintile) of the Deprived Household with potential access to all GP practices in Newcastle, there are differences in the percentages of potential access (i.e. the other four quintiles), particularly in the lower percentages of access between the application of the HSW and PWC techniques. There are differences between the 2nd and the 3rd quintiles, for instance, some Service Areas of GP practices fall into the category of the 2nd quintile applying the PWC, while fall into the category of the 3rd quintile, and vice versa. This could have policy implications if GP practices with lower level of access (such as the 2nd quintile together with the 1st quintile) by the Deprived Household would be selected as GP practices whose access may need to be increased (e.g. through the increase of the size of GP practices) in the city.

On the city scale, the difference in the percentage of each social group with potential accessibility to all GP practices in Newcastle is larger compared to the difference in the number of each social group with potential accessibility between the application of the two HSW and PWC methods illustrated above. Figure 16 shows the difference in the percentage for social groups between the application of the two methods.

Figure 16 The Comparison of the Percentage of each Social Group with Potential Accessibility between the Application of the PWC and HSW Methods at the Ctiy Scale



Source: Own analysis

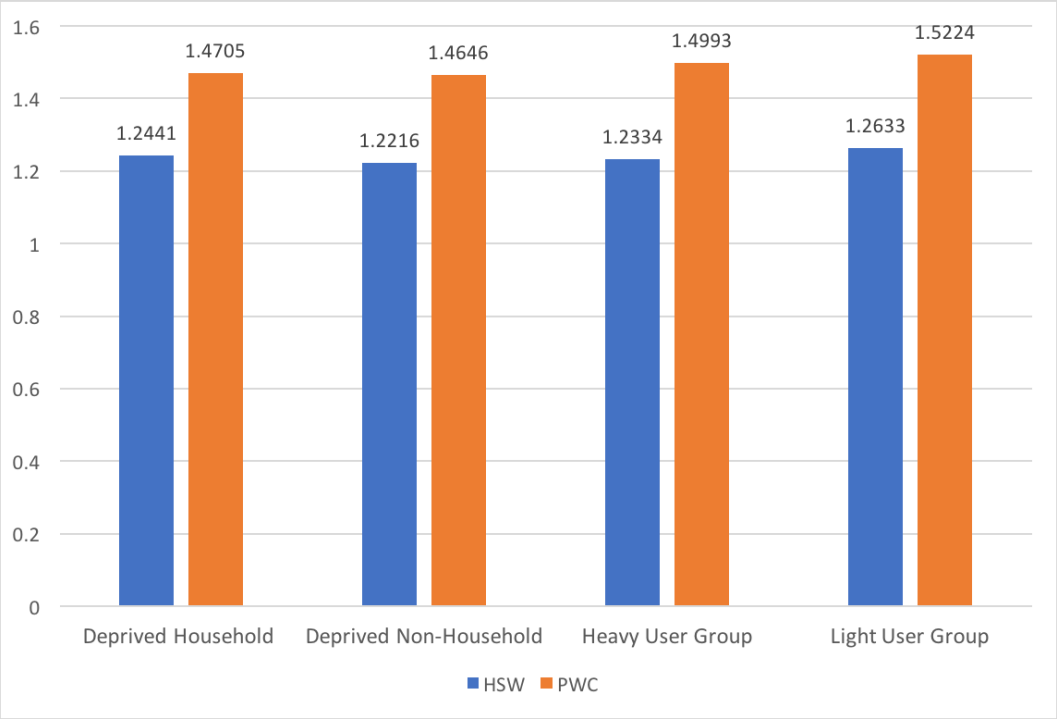
As can been seen from Figure 16 that the difference is large, with an absolute difference of 9-11% for each social group (an absolute increase by 9.34% for the Deprived Household, 10.01% for the Non-Deprived Household, 10.84% for the Heavy User Group and 10.70% for the Light User Group respectively from the result applying the PWC method to HSW method). The larger difference in the percentage is because when calculating the denominator for each social group so as to calculate the percentage of potential accessibility, the PWC method does not count the number of each social group within those Output Areas with their population weighted centroids located outside Service Areas while still with Household Spaces located inside Service Areas (the source of aggregation errors mentioned earlier). Thus, there is underestimation of the denominator taking into consideration the overlay of Service Areas in the city on the city scale applying the PWC method. That's why the total number of each social group involved in the calculation of the denominator applying the PWC method tends to be smaller than the HSW method. Thus, the percentage of each social group applying the PWC method tends to be higher than the HSW method given the difference in the numerator is relatively small between the application of the two methods.

Therefore, even though the difference in the number of each social group with potential accessibility is small, the percent difference in the percentage of each social group with potential accessibility is large (with percent difference of 9-11%) between the application of the HSW and PWC methods. The percentages rather than the numbers of the two related social groups with potential accessibility by Service Area are appropriate to be multiplied by the size weighting of each GP practice and then used for comparisons to assess spatial equity. Because the population sizes of the two related social groups are likely to be different in a city (see Section 6.4 for details). Therefore, the large difference in the percentage of each social group with potential accessibility between the application of the HSW and PWC methods is important when it comes to potential access measurement and spatial equity assessment for a city on the city scale. For policy implications, this suggests that if healthcare service planners or policy makers would like to apply a method to measure the level of access to healthcare services, it would be good to use a more accurate measurement method, or at least to be aware of the difference in the results.

For comparing the application of the PWC and HSW methods in the measurement of potential access, Figure 17 was created to show the difference between the percentage of

each social group with potential access to all GP practices in Newcastle applying the two methods on the city scale.

Figure 17 The Comparison of the Percentage of Social Groups with Potential Access to All GP Practices in Newcastle between the Application of the PWC and HSW Methods on the City Scale



Source: Own analysis

As can be seen from Figure 17, on the city scale, the difference between the percentage of each social group with potential access is large, with a relative difference from 18% to 22% (a relative increase by 18.20% for the Deprived Household, 19.89% for the Non-Deprived Household, 21.56% for the Heavy User Group and 20.51% for the Light User Group applying the PWC method to HSW method). The reason for the difference is similar to the difference between the application of the two methods in measuring the percentage of potential accessibility, as the percentage of each social group with potential access was calculated based on the percentage of each social group with potential accessibility by Service Area multiplying the size weighting of each GP practice (using FTE GPs as the indicator) in the city.

However, as the size weighting for each GP practice is different, the percent difference of PWC method to HSW method in measuring potential accessibility and potential access for each social group is different. Table 19 compares the results from the calculations of

the number and percentage of potential accessibility and potential spatial access to GP practices in Newcastle applying the HSW and PWC techniques.

Table 19 The Difference in the Number and Percentage of Social Groups with Potential Accessibility and Potential Access to GP Practices in Newcastle on the City Scale Applying the HSW and PWC Techniques

Variable	Technique	No. of Potential Accessibility	Total No. of Social Group/Output Area Involved in the Calculation of Potential Accessibility	% of Potential Accessibility	% of Potential access
Deprived Household	HSW	50,643	97,670/ 1,282	51.85	1.2441
	PWC	50,442	82,440/ 1078	61.19	1.4705
Difference		**-201**		**9.34**	**18.20***
Non-Deprived Household	HSW	34,607	69,296/ 1,282	49.94	1.2216
	PWC	34,732	57,932/ 1078	59.95	1.4646
Difference		**125**		**10.01**	**19.89***
Heavy User Group	HSW	24,924	50,677/ 1,282	49.19	1.2334
	PWC	25,453	42,397/ 1078	60.03	1.4993
Difference		**529**		**10.84**	**21.56***
Light User Group	HSW	181,748	354,514/ 1,282	51.27	1.2633
	PWC	183,678	296,397/ 1078	61.97	1.5224
Difference		**1,930**		**10.70**	**20.51***

Source: Own calculation

It is worth noting here that the figures with stars are relative rather than absolute differences in the percentages of the Deprived and Non-Deprived Households with potential access to GP practices in Newcastle on the city scale between the application of the two techniques. They were calculated by subtracting the percentage of potential access applying the HSW technique from the figure applying the PWC technique and then dividing the figure applying the HSW technique.

As shown in Table 19, on the city scale, the differences in the percentage of each social group with potential accessibility and potential access to GP practices in Newcastle are large between the application of the two techniques. When calculating the denominators so as to calculate the percentages of social groups with access, the PWC technique does

not take into account the output areas with population weighted centroids located outside the service area while still with household spaces located inside the service areas. Thus, less output areas involved in the calculation of the denominators applying the PWC technique (1,078 output areas) than the HSW technique (1,282 output areas). That is why the denominator of each social group is smaller applying the PWC technique than the HSW technique. Given the difference in the numerator of each social group between the application of the two techniques is relatively small in Newcastle, the percentage of each social group with potential accessibility and potential access applying the PWC technique is higher than the HSW technique on the city scale.

Therefore, even though the differences in the numbers of social groups with potential accessibility are small, the differences in the percentage of social groups with potential accessibility and potential access are large, with an absolute difference in the percentage of potential accessibility by 9-11% and a relative difference in the percentage of potential access by 18-22% between the application of the PWC and HSW techniques (see Table 19). The large differences in the percentages are important because it is the percentages rather than the numbers of social groups with access that are comparable due to the difference in population size of each social group in a city. For policy implications, the large differences suggest that if service planners or policy makers would like to apply a method to measure access to services, it would be good to use a more accurate population weighting technique, or at least be aware of the implication of using the PWC technique.

The above is the comparison between the application of the HSW and PWC methods in the measurement of potential accessibility and potential access. The focus of the upcoming section will be on the implication of involving the overlay of Service Areas in population estimation and the measurement of potential accessibility based on the results calculated in the previous sections of this chapter.

6.7 Implications of Involving the Overlay of Service Areas for Population Estimation and Potential Accessibility Measurement

As mentioned in the previous sections, this research uses individual Service Areas instead of merged Service Areas for the calculation of potential accessibility and potential access. Because the location of population and social groups inside or outside the overlay of Service Areas can affect the level of potential access. Population and social groups located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003). Thus, it is

necessary to take into account the overlay of different Service Areas in addition to the size of GP practices in access measurement.

Section 6.4 illustrated how to take into account the overlay of Service Areas in potential accessibility measurement conceptually drawing upon Luo and Wang's (2003) research. In this section, how the overlay of different Service Areas affects population estimation inside Service Areas and the calculation of potential accessibility will be illustrated through statistical and geographical analysis using Service Areas of GP practices in Newcastle as an example. This will be achieved by comparing the percentages between population inside a merged area of overlaid Service Areas and population inside the areas of the same individual Service Areas that have been calculated in the previous sections.

As mentioned in the previous sections, the application of the HSW method involves 2 to 4 overlaid Service Areas and the application of the PWC method involves calculations on the 2 to 3 overlaid Service Areas of all GP practices in Newcastle. The logic of involving the overlaid Service Areas is the same between the application of the two methods and between the calculation for population (residents) and its subgroups (social groups). Thus, to simplify the illustration and analysis, an example will be given by comparing the percentages between population located inside a merged layer of two Service Areas (rather than multiple, e.g. three or four overlaid Service Areas) and population located inside the two individual Service Areas. Service Area 5 and 33 will be chosen for the comparison because these two overlaid Service Areas have no overlay with other Service Areas. As the population inside Service Areas 5 and 33 by Output Area (the numerator) and the total population involved in the calculation of the population inside Service Areas 5 and 33 by Output Area taking into account the overlay of all Service Areas in Newcastle (the denominator) have been calculated in Section 6.5.1 applying the HSW technique, the results will be used for the illustration here.

The percentages of population inside the Service Areas 5 and 33 by Output Area (1282 OAs) were calculated by dividing the population inside the 5 and 33 Service Areas by Output Area by the total population involved in the calculation of the numerator taking into account the overlay of Service Areas in Newcastle. The percentages of population inside the merged Service Area of 5 and 33 by Output Area were calculated by dividing the population inside the merged Service Area of 5 and 33 by Output Area by the total population in Newcastle (910 OAs). The process and the results of the calculations can be referred to Table 20.

Table 20 The Numbers and Percentages of Population inside the Service Areas 5 and 33 and inside the Merged Service Area of 5 and 33 by Output Area in Newcastle Applying the HSW Technique on the City Scale

OA Code	Population inside Service Areas 5 and 33 (by Output Area)	Total Population Involved in the Calculation of the Numerator in Newcastle (1282 Output Areas Involved)	% of Population inside Service Areas 5 and 33	Population inside the Merged Service Area of 5 and 33 (by Output Area)	Total Population in Newcastle (910 Output Areas in the City)	% of Population inside the Merged Service Area of 5 and 33
E00042043	65	405105	0.0160	65	280226	0.0232
E00042048	131	405105	0.0323	96	280226	0.0343
E00042051	123	405105	0.0304	123	280226	0.0439
E00042054	117	405105	0.0289	117	280226	0.0418
E00042245	28	405105	0.0069	28	280226	0.0100
E00042324	187	405105	0.0462	29	280226	0.0103
E00042329	18	405105	0.0044	18	280226	0.0064
E00042330	91	405105	0.0225	91	280226	0.0325
E00042334	74	405105	0.0183	74	280226	0.0264
E00042335	142	405105	0.0351	142	280226	0.0507
E00042336	155	405105	0.0383	155	280226	0.0553
E00042337	109	405105	0.0269	109	280226	0.0389
E00042338	206	405105	0.0509	46	280226	0.0164
E00042343	6	405105	0.0015	6	280226	0.0021
E00042347	165	405105	0.0407	35	280226	0.0125
E00042513	8	405105	0.0020	8	280226	0.0029
E00042540	16	405105	0.0039	16	280226	0.0057
E00042685	54	405105	0.0133	54	280226	0.0193
E00042686	216	405105	0.0533	121	280226	0.0432
E00042687	217	405105	0.0536	122	280226	0.0435
E00042688	108	405105	0.0267	69	280226	0.0246
E00042689	176	405105	0.0434	134	280226	0.0478
E00042690	129	405105	0.0318	129	280226	0.0460
E00042691	30	405105	0.0074	30	280226	0.0107
E00042694	33	405105	0.0081	33	280226	0.0118
E00042702	203	405105	0.0501	84	280226	0.0300
E00042703	240	405105	0.0592	120	280226	0.0428
E00042704	226	405105	0.0558	115	280226	0.0410
E00042705	262	405105	0.0647	121	280226	0.0432

Source: Own calculation

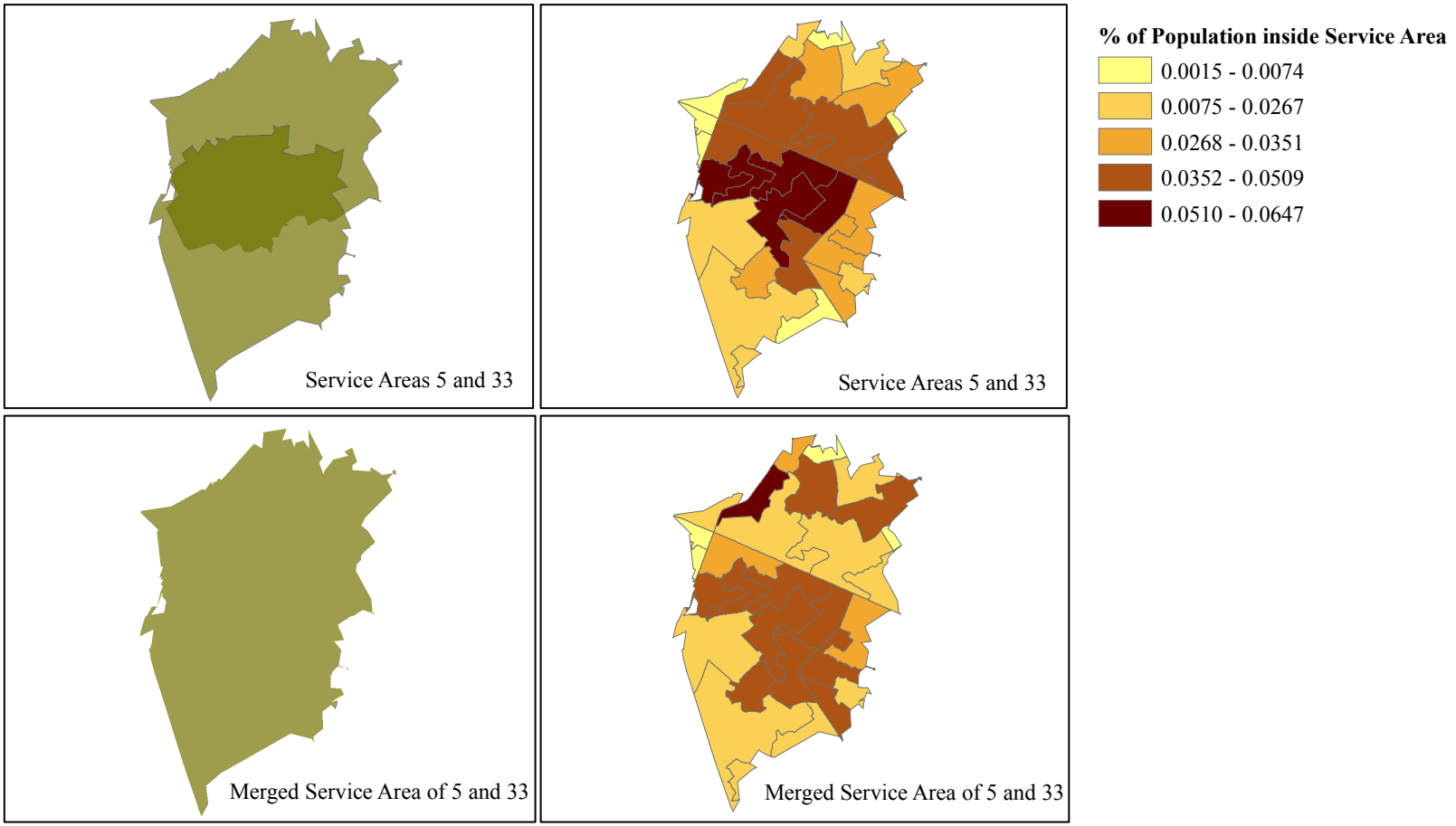
It is worth noting here that the percentages are small because the denominators are the total population involved in the calculation of the numerator in Newcastle (1282 Output Areas involved) in the case of the individual Service Areas 5 and 33 or the total population in Newcastle (910 Output Areas in the city) in the case of the merged Service Area of 5 and 33.

As can be seen from Table 20, the populations of some Output Areas located inside Service Areas 5 and 33 are larger than the populations of the Output Areas located inside the merged Service Area of 5 and 33, such as the Output Areas with OA Code of

E00042048 and E00042324. This is because the calculation of the population of the Output Areas in question located inside Service Areas 5 and 33 involves double calculation of the population within those Output Areas located inside the overlay of Service Areas 5 and 33. While for Output Areas that have the same population estimation inside Service Areas 5 and 33 as population estimation inside the merged Service Area of 5 and 33, no overlay involved in the calculations, meaning that those Output Areas are located within either Service Area 5 or Service Area 33 outside the overlay of the two Service Areas.

The total population inside Service Areas involved in the calculation on the city scale is larger taking into account the overlay of Service Areas (involving 1,282 Output Areas more than the 910 Output Areas in the city) as it involves not only counting once but also multiple counting of the population within Output Areas located inside the overlay Service Areas on the city scale. The double counting of the population of Output Areas located inside the overlay of Service Area 5 and Service Area 33 is an example. Thus, the involvement of the overlay of Service Areas can result in different percentages of population inside Service Areas on the city scale. Map 15 visualizes such difference.

Map 15 The Comparison between the Percentages of the Populations inside Service Areas 5 and 33 and inside the Merged Service Area of 5 and 33 by Output Area in Newcastle Applying the HSW Technique



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The Service Areas are created against half a mile walking distance from GP practices.

In Map 15, the two comparative maps on the left are Service Areas, with individual Service Areas 5 and 33 and the overlay of the two Service Areas on the top left-hand side (the darker green color where the two Service Areas intersect) and the merged Service Area of 5 and 33 on the bottom left hand side. The two maps on the right visualize the percentage of population inside Service Areas, with the top right-hand size involving the overlay of the two Service Areas 5 and 33 in the percentage calculation while the bottom two maps showing the percentage calculation based on the merged Service Area 5 and 33 with no involvement of the overlay. For comparison, the classification in the legend of the percentage of population inside the merged Service Area of 5 and 33 was adjusted to the quantile of the percentage of population inside Service Area of 5 and 33.

It can be seen from comparing the top two maps with the bottom two maps that the highest percentages of population inside Service Areas (meaning with potential accessibility) are concentrated in the area with Output Areas located inside the overlay of Service Area of 5 and 33. This is in accordance with Luo and Wang's (2003) study that population located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003).

It is worth noting here that in applying the HSW method, the weight of an Output Area with access is assigned based on the number of Household Spaces located inside the overlap of the Output Area and Service Areas to the total number of Household Space located inside the Output Area. So, double or multiple counting of population within Output Areas located inside the overlay of Service Areas (i.e. residents with potential accessibility) applying the method may involve the assigning of different weights to the same Output Area when it is overlapped with different Service Areas. Thus, double or multiple counting does not necessarily mean that the same weight would be assigned to an Output Area for more than once. It can be the case if the Output Area is located fully inside the overlays, while cannot be the case if it is located partially inside the overlays. Besides, the denominator could be different with or without the involvement of the overlay of Service Areas in the calculation of the percentage of potential accessibility. The larger number of the denominators when the overlay of Service Areas is involved (involving 1,282 Output Areas more than the 910 Output Areas in the city) in the calculation of the numerators explains the higher percentages of several Output Areas with population inside the merged Service Area of 5 and 33 than Service Area of 5 and 33

as the differences in the denominators are larger than the difference in the numerators in those cases.

6.8 Summary

This chapter illustrated and compared the HSW and PWC techniques and applied the two techniques in the context of the measurement of potential accessibility and potential access on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) using GP practices in Newcastle as a case study. The number of population inside Service Areas and the percentage of potential accessibility to all GP practices for social groups were calculated and compared to identify a more accurate population estimation technique and potential accessibility measurement method.

Based on the conceptual and empirical analysis and comparisons between the application of the HSW and PWC techniques, the research has demonstrated that the HSW technique is more accurate than the PWC technique in estimating population inside Service Areas and measuring potential accessibility and potential access. Because it reduces aggregation errors by taking into consideration Houses in Multiple Occupancy of residential buildings by dwelling in use and estimating population inside Service Areas including partial access apart from full and no access compared to the application of the PWC technique.

As the HSW technique has been demonstrated as a more accurate method for measuring potential access, the results calculated in this chapter applying the HSW method will be used to illustrate how spatial equity can be assessed based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) in the next chapter.

Chapter Seven: The Illustration of How to Assess Spatial Equity Integrating Quality, and the Development and Application of the Spatial Equity Assessment Framework for Policy Recommendations

7.1 Overview

This chapter will focus on the illustration of how to assess spatial equity based on the comparison of the percentage of social groups with potential access (potential accessibility integrating size) to healthcare services integrating quality based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) on the city scale. GP practices in Newcastle will be used as a case study. The purposes of this chapter are to illustrate how to assess spatial equity based on the conceptual framework and how to integrate the quality of healthcare services into the assessment so as to develop the GIS-based Spatial Equity Assessment Framework and illustrate how it can be applied to provide policy recommendations.

The illustration will draw upon Nicholls' (2001) research on combining potential access measurement and equity assessment (see Chapter Six for more details). As the HSW method has been demonstrated as more accurate in measuring potential access than the PWC method, the percentages of social groups with potential access to GP practices in Newcastle calculated applying the HSW method in the previous chapter will be used to illustrate how to assess spatial equity integrating quality here in this chapter.

There are four main sections in this chapter. Section Two will emphasize the illustration of the assessment of the *equality*, *need* and *demand* conceptions of spatial equity by comparing the percentages of the Deprived and Non-Deprived Households (*equality* and *need* conceptions) and the Heavy and Light User Groups (*equality* and *demand* conceptions) with potential access to GP practices in Newcastle respectively. The SPSS Mann-Whitney U will be performed to test the difference and the Cohen's Index will be applied to calculate the effect size to understand the magnitude of differences between the two related social groups under comparison when necessary.

Section Three will focus on the illustration of how to integrate the quality of GP practices into the assessment of the *equality*, *need* and *demand* conceptions of spatial equity by comparing the percentages of the Deprived and Non-Deprived Households and the Heavy and Light User Groups with potential access to GP practices of good quality (GP practices with 'Good' and 'Outstanding' CQC ratings) in Newcastle respectively. The SPSS Mann-Whitney U will be performed to test the difference and the Cohen's Effect

Size Index will be applied to calculate the effect size to understand the magnitude of differences between the two related social groups under comparison when necessary.

Section Four will emphasize the analysis of the findings from the spatial equity assessment of GP practices in Newcastle integrating quality and propose policy recommendations based on the result of spatial equity assessment. Section Five will focus on summarizing the whole process from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework applying the HSW method. The summary will lead to the development of the GIS-based Spatial Equity Assessment Framework. The assessment framework will be presented in a more generic way as it has potential to extend from healthcare services to other services. Also summarized will be how to use the result from spatial equity assessment to provide policy recommendations for cities on the city scale.

7.2 Spatial Equity Assessment of GP Practices – *Equality*, *Need* and *Demand* Conceptions

In this section, how spatial equity can be assessed based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) on the city scale will be illustrated using GP practices in Newcastle as a case study. Drawing upon Nicholls' (2001) model of combining potential access measurement and equity assessment mentioned earlier, two main aspects will be adapted to the context of this research.

First, although size is involved in the measurement of potential access in Nicholls' (2001) research, it is more related to physical size of public services (i.e. public parks in Nicholls' case) when measuring potential access. While, the size of healthcare services is more related to availability of the services rather than physical size. Thus, in the case study of this research, availability will be measured using size weighting of GP practices in Newcastle on the city scale, that is dividing the FTE GPs (an indicator used to measure availability) in each GP practice by the total number of the FTE GPs in the city (see Chapter Six for more details).

Second, Nicholls' (2001) research only assesses the *equality* and *need* conceptions of spatial equity by comparing the percentages of each social group with and without access to public services (i.e. public parks). Social groups identified as the "most likely to be in 'need' of better than average access to public parks are non-Whites, those earning low

incomes (approximated by those who rent as opposed to own their home, and those whose property or rental value is lower than average), the young and the elderly, and those residing in more densely populated areas and less likely to have access to a private garden" in Nicholls' (2001:210-211) research. Accordingly, nine variables that are utilized in the equity analysis include: "i) population density; ii) per cent non-White (i.e., Blacks, Asians, American Indians, and all other races); iii) per cent Black; iv) per cent Hispanic; v) per cent under age 18; vi) per cent over age 64; vii) per cent of housing units renter occupied; viii) mean housing value (for owner occupied units); and, ix) mean contract rent (for rental units)"[28] (Nicholls, 2001:211).

Different from Nicholls' (2001) conceptual framework and choice of variables, this research uses socio-economic factor to assess the *equality* and *need* conceptions and uses demographic factor to assess the *equality* and *demand* conceptions based on the conceptual framework of spatial equity (see Chapter Five for the justifications). To be more specific, the 2011 Census Data deprivation datasets (the Deprived and Non-Deprived Household) are used to assess the *equality* and *need* conceptions because its four characteristics of households (Employment, Education, Health and Disability, and Housing) reflect the level of needs through socio-economic status; the age datasets (age groups under 5 and over 74 represent the Heavy User Group and the rest age groups at 5-74 represent the Light User Group) are used to assess the the *equality* and *demand* conceptions because age groups can reflect the level of demands for healthcare services through consultation rates (Figueroa et al., 2002; Gregory et al., 2000; Love and Lindquist, 1995; Office for National Statistics, 2011; Rogers, *et al*., 1999).

Thus, according to the conceptual framework of spatial equity adopted in this research, the percentages of the Deprived Household and the Non-Deprived Household with potential access on the city scale are compared to assess the *equality* and *need* conceptions; the percentages of the Heavy User Group and the Light User Group with potential access on the city scale are compared to assess the *equality* and *demand* conceptions of spatial equity. In this section, GP practices in Newcastle will be used as a case study. As the HSW method has been demonstrated as more accurate in measuring potential access than the PWC method, the percentages of social groups with potential

[28] "Housing tenure and value were used as a proxy for income since income data are not available for census blocks" (Nicholls, 2001:211).

access to all GP practices in Newcastle calculated applying the HSW method in the previous chapter will be used for illustrating spatial equity assessment here in this section.

7.2.1 Spatial Equity Assessment of All GP Practices in Newcastle – Equality and Need Conceptions

For assessing the *equality* and *need* conceptions of spatial equity for all GP practices in Newcastle, the percentages of the Deprived and Non-Deprived Households with potential access to all GP pratctices in the city applying the HSW method will be compared. The percentages can be referred to Figure 17 in Chapter Six, which shows that the percentages of the Deprived and Non-Deprived Households with potential access to all GP pracitces in Newcastle are 1.2441% and 1.2216% respectively applying the HSW method on the city scale.

According to the conceptual framework of spatial equity adopted in this research, a *need-based equitable access* would be suggested when the percentage of the Deprived Household with potential access is significantly higher than the percentage of the Non-Deprived Household with potential access to all GP practices in a city; a *need-based equal access* would be suggested when the percentage of the Deprived Household with potential access is higher than the percentage of the Non-Deprived Household with potential access to all GP practices in a city while the difference is not significant; a *need-based inequitable access* would be suggested when the percentage of the Deprived Household with potential access is lower than the percentage of the Non-Deprived Household with potential access to all GP practices in the city on the city scale.

As the percentage of the Deprived Household is higher than the Non-Deprived Household in potential access to all GP practices in Newcastle, the SPSS Mann-Whitney U was performed to test the difference so as to assess the *equality* and *need* conceptions of spatial equity of all GP practices in the city on the city scale. This was achieved by comparing the percentages of the Deprived and Non-Deprived Households with potential access to the 44 GP practices in the city with the following null hypothesis: There is no significant difference between the percentages of the Deprived and Non-Deprived Households with potential access to all GP practices in Newcastle. Table 21 shows the output of the Mann-Whitney U test.

Table 21 The Output of Mann-Whitney U Test for Assessing the *Equality* and *Need* Conceptions of All GP Practices in Newcastle

Method	Variable	Median Value of Variable		Mann-Whitney U Test	2-tailed p Value
		Deprived Household with Potential Access	Non-Deprived Household with Potential Access		
HSW	Percent Deprivation	.020800	.018200	939.500	.812

Source: Own analysis

As can be seen from Table 21, the *p* value (Asymp. Sig. (2-tailed)) of the test is .812 (>0.05), so the null hypothesis was accepted. Thus, there is no significant difference between the percentages of the Deprived and Non-Deprived Households with potential access to all GP practices in Newcastle on the city scale. This means that even though the percentage of the Deprived Household with potential access is higher than the percentage of the Non-Deprived Household with potential access to all GP practices in the city on the city scale, the difference is not significant.

The Mann-Whitney U only tests the significance of the difference, which may be not enough for it only examines the likeability of the findings are due to chance, so the effect size was calculated to understand the magnitude of differences. The combination of statistical significance and effect size can help understand the full impact of a study (Sullivan and Feinn, 2012). As Cohen's Effect Size Index (one of the most common effect size indices) can be used to find the sample size required for sufficient power for a study (ibid.), it was used for the calculation. Table 22 shows the mean values and standard deviations obtained by running the Descriptive function in SPSS for the effect size calculation.

Table 22 Descriptive Statistics

Variable	Number	Mean	Std. Deviation
Percent Deprivation			
Deprived Household	44	0.028270	0.0246267
Non-Deprived Household	44	0.027766	0.0250965

Source: Own calculation

The following equation of Cohen's Effect Size Index was used for the calculation; the result of the effect size is 0.02.

$$d = {M_1 - M_2}/{s} \qquad \textbf{Equation 7}$$

Where,

d = effect size

M_1-M_2 = the difference between the group means (M)

s = the standard deviation of either group

Table 23 shows Sullivan and Feinn's (2012:281) interpretation about the result of the effect size calculation.

Table 23 Differences Between Groups, Effect Size Measured by Glass's Δ

Relative Size	Effect Size	Percentile	% of Non-overlap
	0	50	0
Small	0.2	58	15
Medium	0.5	69	33
Large	0.8	79	47
	1.0	84	55
	1.5	93	71
	2.0	97	81

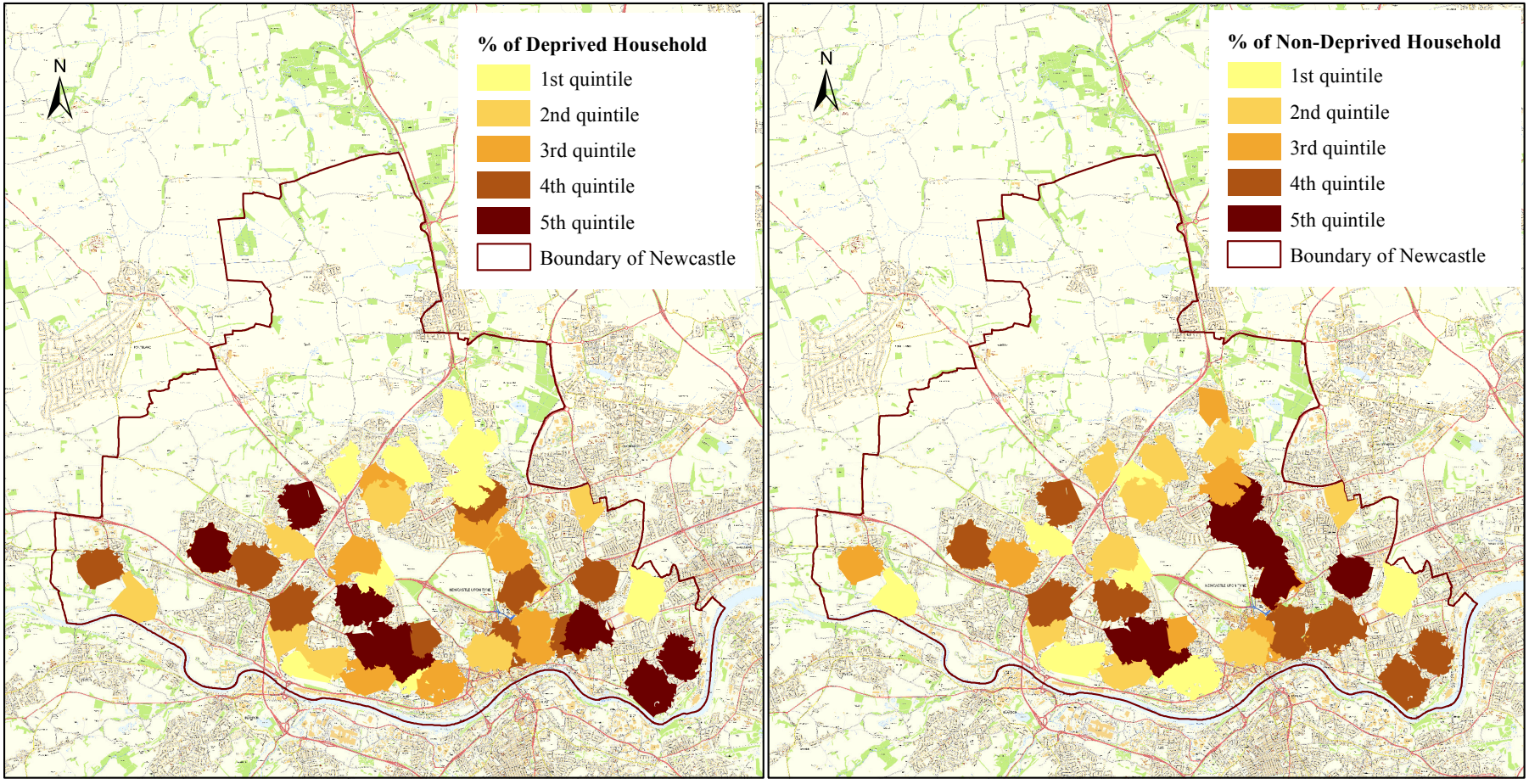
Source: Sullivan and Feinn's (2012:281)

According to Sullivan and Feinn's (2012:281) interpretation, there is no difference between the two groups (effect size is 0) as "the mean of group 2 is at the 50th percentile of group 1, and the distributions overlap completely (100%)". This echoes to the result of the Mann-Whitney U test (no significant difference between the two groups). Therefore, based on the conceptual framework of spatial equity adopted in this research, a *need-based equal access* rather than a *need-based equitable access* was suggested in terms of potential access to all GP practices in Newcastle on the city scale.

Map 16 visualizes the distribution of the difference in the percentages of the Deprived and Non-Deprived Households with potential access to all GP practices by Service Area in Newcastle on the city scale. The use of quintiles in the classification of the legend draws upon Fransen et al.'s (2015) approach on comparing the spatial distribution of the accessibility to daycare centers between the application of the 2SFCA (two-step floating catchment area) and CB2SFCA (commuter-based version of the 2SFCA) methods. It is worth noting here that it is possible that the percentage of the Deprived Household or the

percentage of the Non-Deprived Household with potential access can be put into different quintiles if other data classification schemes are used. But respective quintiles are comparable between the percentage of the Deprived Household and the percentage of the Non-Deprived Household with potential access because the same classification scheme is applied to both groups under comparison.

Map 16 The Distribution of the Difference in the Percentages of the Deprived and Non-Deprived Households with Potential Access to All GP Practices by Service Area in Newcastle on the City Scale



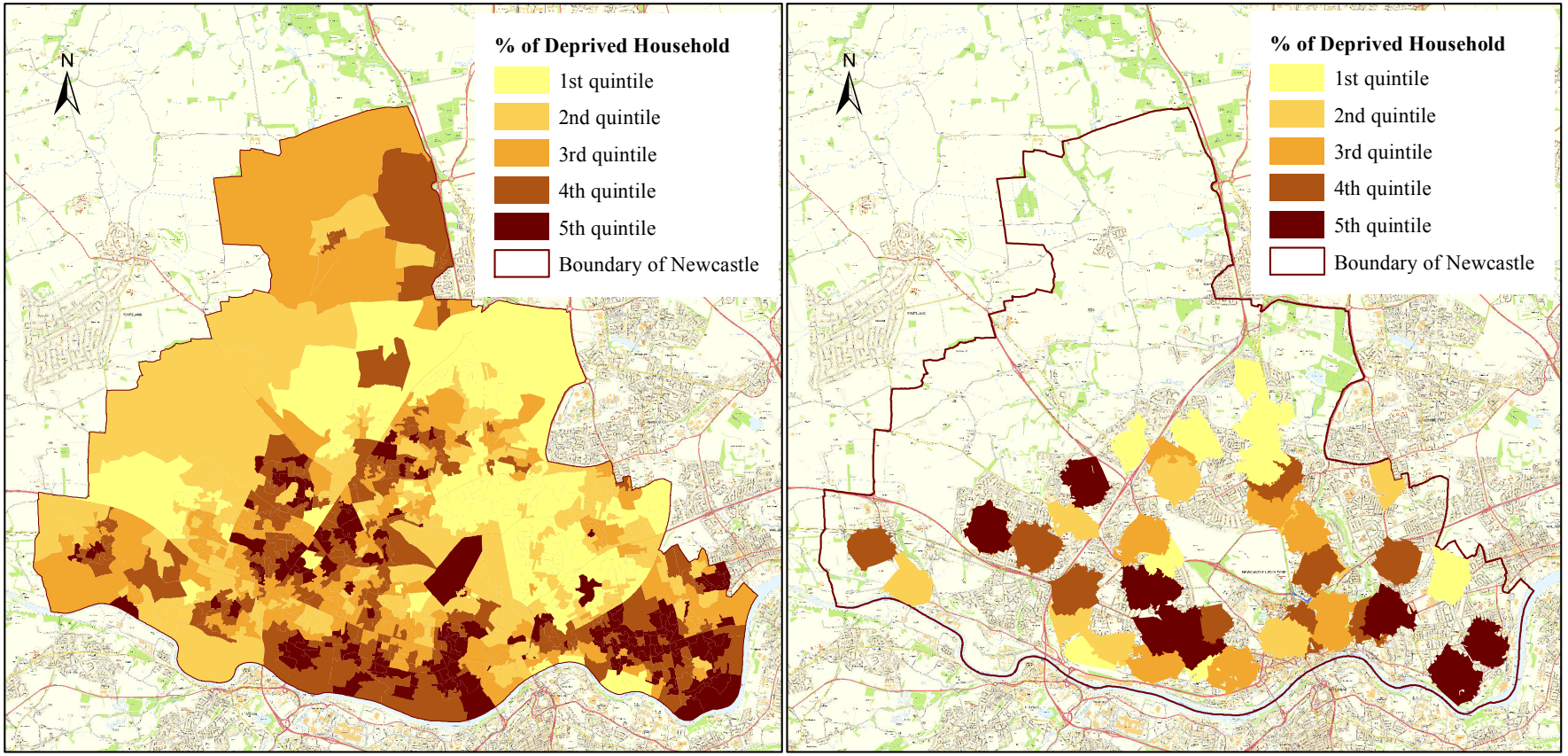
This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The deprivation data is the 2011 Census Data downloaded from the Infuse (2016).

As can be seen from Map 16, the darker the color the higher the percentage of the social group classified by deprivation with potential access to all GP practices by Service Area in Newcastle on the city scale. Thus, the map indicates an uneven distribution of the Deprived and Non-Deprived Households with higher and lower percentages of potential access in the city.

To further explain the result of the assessment of the *equality* and *need* conceptions of spatial equity, a GIS map (Map 17) was created to compare the percentage of the Deprived Household in Newcastle and the percentage of the Deprived Household with potential access to all GP practices by Service Area in the city on the city scale. The comparison in Map 17 shows substantial overlays between the distribution of the Deprived Household with higher percentages (the 4^{th} and 5^{th} quintiles) of potential access to all GP practices in Newcastle with the distribution of higher percentages (the 4^{th} and 5^{th} quintiles) of the Deprived Household in the city, particularly around the riverside and the southwestern part of the city.

The overlays, to some extent, contribute to the higher percentages of the Deprived Household than the Non-Deprived Household with potential access to all GP practices in Newcastle. This reflects the result of the assessment of the *equality* and *need* conceptions, the *need-based equal access* in terms of potential access to all GP practices in Newcastle on the city scale (the scenario where the percentage of the Deprived Household is higher than the Non-Deprived Household in potential access to all GP practices in the city on the city scale while the difference is not significant).

Map 17 The Comparison between the Percentage of the Deprived Household in Newcastle and the Percentage of the Deprived Household with Potential Access to all GP Practices by Service Area in Newcastle on the City Scale



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The deprivation data is the 2011 Census Data downloaded from the Infuse (2016).

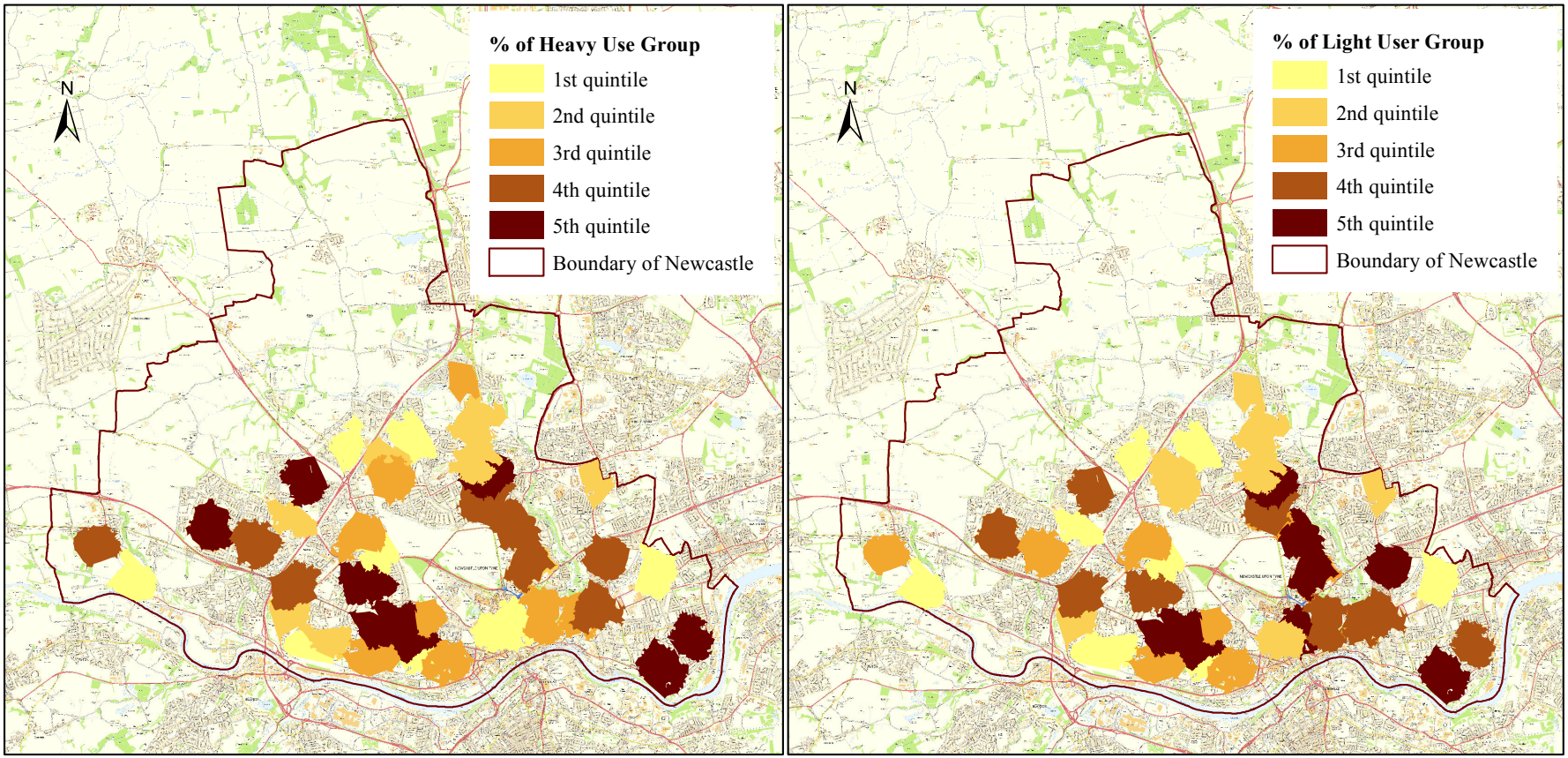
7.2.2 Spatial Equity Assessment of All GP Practices in Newcastle – Equality and Demand Conceptions

Concerning the assessment of the *equality and demand* conceptions of all GP practices in Newcastle, the percentages of the Heavy and Light User Groups with potential access to all GP practices in the city applying the HSW method were compared. The percentages can be referred to Figure 17 in Chapter Six, which shows that the percentages of the Heavy and Light User Groups with potential access to all GP practices in Newcastle are 1.2334% and 1.2633% respectively applying the HSW method.

According to the conceptual framework of spatial equity adopted in this research, a *demand-based equitable access* would be suggested when the percentage of the Heavy User Group with potential access is significantly higher than the percentage of the Light User Group with potential access to all GP practices in a city; a *demand-based equal access* would be suggested when the percentage of the Heavy User Group with potential access is higher than the percentage of the Light User Group with potential access to all GP practices in a city while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *demand-based inequitable access* would be suggested when the percentage of the Heavy User Group with potential access is lower than the percentage of the Light User Group with potential access to all GP practices in the city on the city scale.

As the percentage of the Heavy User Group with potential access is lower than the percentage of the Light User Group with potential access to all GP practices in Newcastle, a *demand-based inequitable access* was suggested in terms of potential access to all GP practices in Newcastle based on the conceptual framework of spatial equity. Map 18 visualizes the distribution of the difference in the percentages of the Heavy and Light User Groups with potential access to all GP practices by Service Area in the city on the city scale.

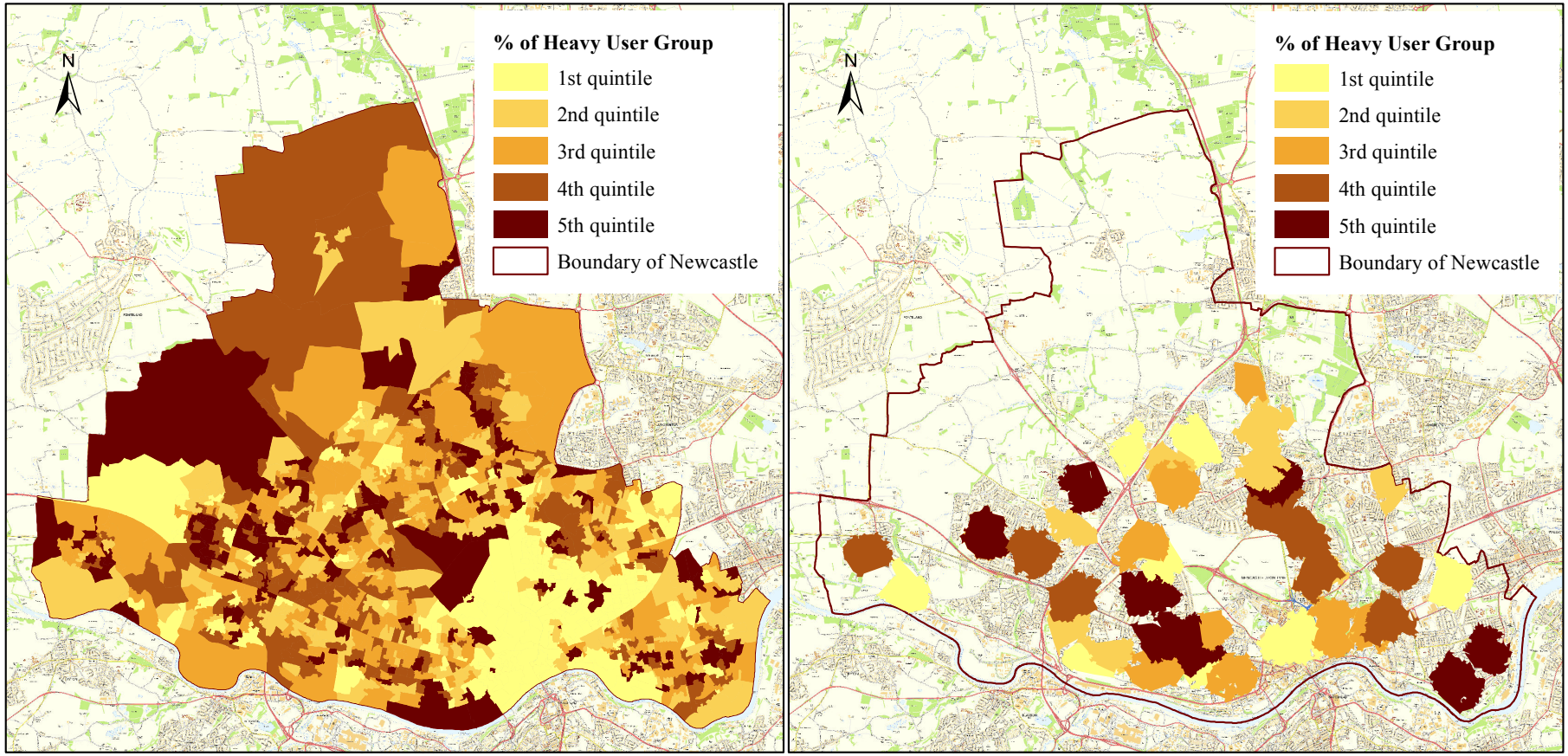
Map 18 The Distribution of the Difference in the Percentages of the Heavy and Light User Groups with Potential Access to All GP Practices in Newcastle by Service Area on the City Scale



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The age data is the 2011 Census Data downloaded from the Infuse (2017).

As can be seen from Map 18, the darker the color the higher the percentage of the social group classified by age with potential access to all GP practices in Newcastle on the city scale. Thus, the map indicates an uneven distribution of the Heavy and Light User Groups with higher and lower percentages of potential access in the city on the city scale. To further explain the result of the assessment of the *equality* and *demand* conceptions of spatial equity, a GIS map (Map 19) was created to compare the percentage of the Heavy User Group in Newcastle and the percentage of the Heavy User Group with potential access to all GP practices by Service Area in the city on the city scale.

Map 19 The Comparison between the Percentage of the Heavy User Group in Newcastle and the Percentage of the Heavy User Group with Potential Access to all GP Practices by Service Area in Newcastle on the City Scale



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The age data is the 2011 Census Data downloaded from the Infuse (2017).

The comparison in Map 19 shows no substantial overlay between the distribution of the Heavy User Group with higher percentages (the 4th and 5th quintiles) of potential access to all GP practices in Newcastle with the distribution of higher percentages (the 4th and 5th quintiles) of the Heavy User Group in the city on the city scale. No substantial overlay in this scenario, to some extent, is in accordance with the smaller percentage of the Heavy User Group than the Light User Group with potential access to all GP practices in Newcastle on the city scale. This reflects the result of the assessment of the *equality* and *demand* conceptions, the *demand-based inequitable access* in terms of potential access to all GP practices in Newcastle on the city scale (the scenario where the percentage of the Heavy User Group is lower than the Light User Group in potential access to all GP practices in the city on the city scale).

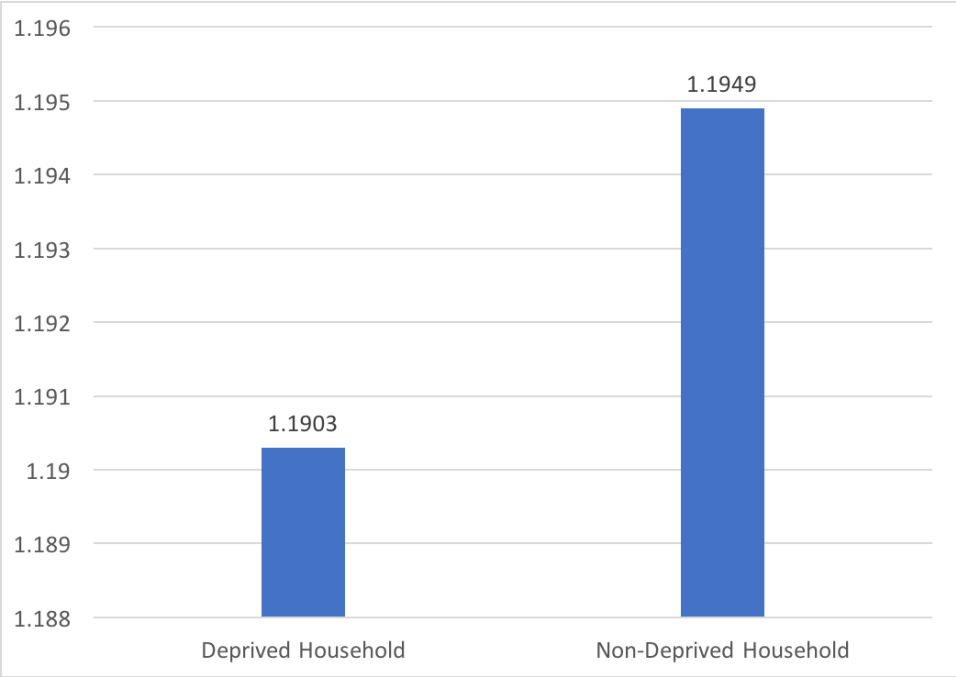
7.3 Spatial Equity Assessment of GP Practices - Integrating Quality

This section will emphasize the illustration of how to integrate the quality of GP practices into the assessment of the *equality*, *need* and *demand* conceptions of spatial equity based on the conceptual framework adopted in this research. The assessment involves GP practices of good quality (combining the GP practices with 'Good' and 'Outstanding' CQC ratings) in Newcastle that were selected from all GP practices in the city based on the data used in the previous section.

7.3.1 Spatial Equity Assessment of GP Practices of Good Quality in Newcastle – Equality and Need Conceptions

For assessing the *equality* and *need* conceptions of spatial equity for GP practices of good quality in Newcastle, the percentages of the Deprived and Non-Deprived Households with potential access to GP practices of good quality in the city will be compared. The percentages were calculated by adding up the subtotal of the 42 GP practices of good quality selected from all the 44 GP practices in the city. The result can be referred to Figure 18, which shows that the percentages of the Deprived Household and Non-Deprived Households with potential access to GP practices of good quality in Newcastle on the city scale are 1.1903% and 1.1949% respectively applying the HSW method.

Figure 18 The Percentages of the Depriven and Non-Deprived Households with Potential Access to GP Practices of Good Quality in Newcastle on the City Scale Applying the HSW Method



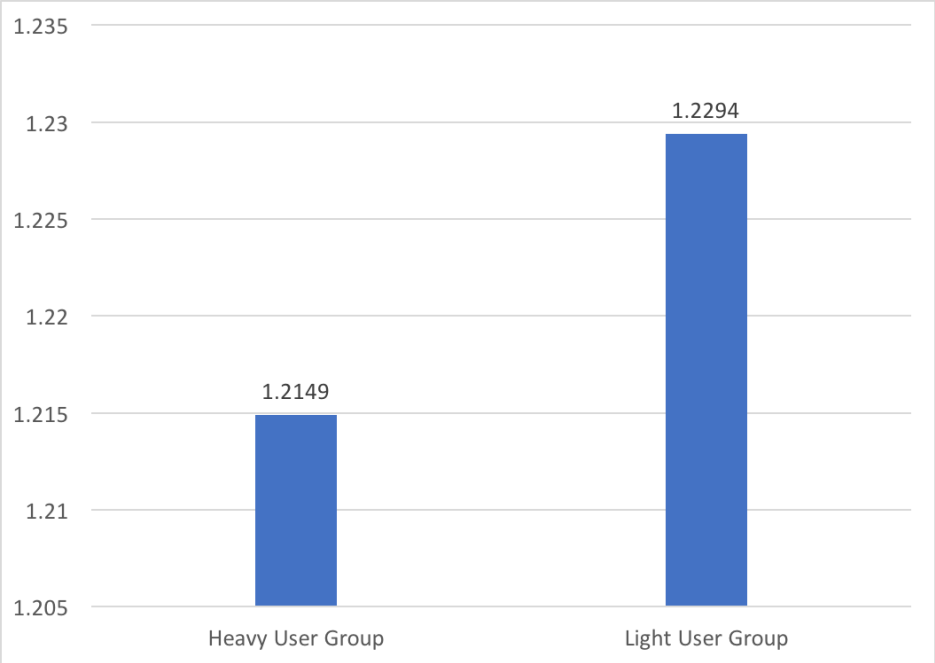
Source: Own analysis

The percentage of the Deprived Household with potential access (1.1903%) is lower than the percentage of Non-Deprived Household with potential access (1.1949%) to GP practices of good quality in Newcastle on the city scale. Thus, a *need-based inequitable access* was suggested in terms of potential access to the GP practices of good quality in the city based on the conceptual framework of spatial equity adopted in this research (illustrated in detail in the previous section).

7.3.2 Spatial Equity Assessment of GP Practices of Good Quality in Newcastle – Equality and Demand Conceptions

To assess the *equality* and *demand* conceptions for GP practices of good quality in Newcastle, the percentages of the Heavy and Light User Groups with potential access to the 42 GP practices of good quality in the city on the city scale will be compared. The percentages were calculated by adding up the subtotal of the 42 GP practices of good quality selected from all the 44 GP practices in Newcastle. The result can be referred to Figure 19, which shows that the percentages of the Heavy and Light User Groups with potential access to GP practices of good quality in Newcastle on the city scale are 1.2149% and 1.2294% respectively applying the HSW method.

Figure 19 The Percentages of Heavy and Light User Groups with Potential Access to GP Practices of Good Quality in Newcastle on the City Scale Applying the HSW Method



Source: Own analysis

The percentage of the Heavy User Group with potential access (1.2149%) is lower than the percentage of Light User Group (1.2294%) with potential access to GP practices of good quality in Newcastle on the city scale. Thus, a *demand-based inequitable access* was suggested in terms of potential access to the GP practices of good quality in the city on the city scale based on the conceptual framework of spatial equity adopted in this research (illustrated in detail in the previous section).

7.4 Analysis of Spatial Equity Assessment of GP Practices in Newcastle Integrating Quality and the Illustration of How to Provide Policy Recommendations Using the Result

This section will focus on discussing the findings, analysis of spatial equity assessment of all GP practices and GP practices of good quality in Newcastle on the city scale, and the illustration of how to use the result of spatial equity assessment to make policy recommendations for cities on the city scale. Based on the above assessment of spatial equity in accordance with the *equality*, *need* and *demand* conceptions of the conceptual framework of spatial equity, the result of spatial equity assessment of all GP practices and GP practices integrating quality (GP practices of good quality) in Newcastle was summarized in Table 24.

Table 24 The Result of Spatial Equity Assessment of GP Practices Integrating Quality in Newcastle on the City Scale

Type of GP Practice	Conception Assessed	Variable	Median Value of Variable with Potential access	Result of Spatial Equity Assessment
All	***Equality* and *Need***	Percent Deprivation	% of Deprived Household (1.2441) is higher than Non-Deprived Household (1.2216)	*Need-based Equal Access*
	Equality* and *Demand	Percent Age Group	% of Heavy User Group (1.2334) is lower than Light User Group (1.2633)	*Demand-based Inequitable Access*
Good Quality	***Equality* and *Need***	Percent Deprivation	% of Deprived Household (1.1903) is lower than Non-Deprived Household (1.1949)	*Need-based Inequitable Access*
	Equality* and *Demand	Percent Age Group	% of Heavy User Group (1.2149) is lower than Light User Group (1.2294)	*Demand-based Inequitable Access*

Source: Own analysis

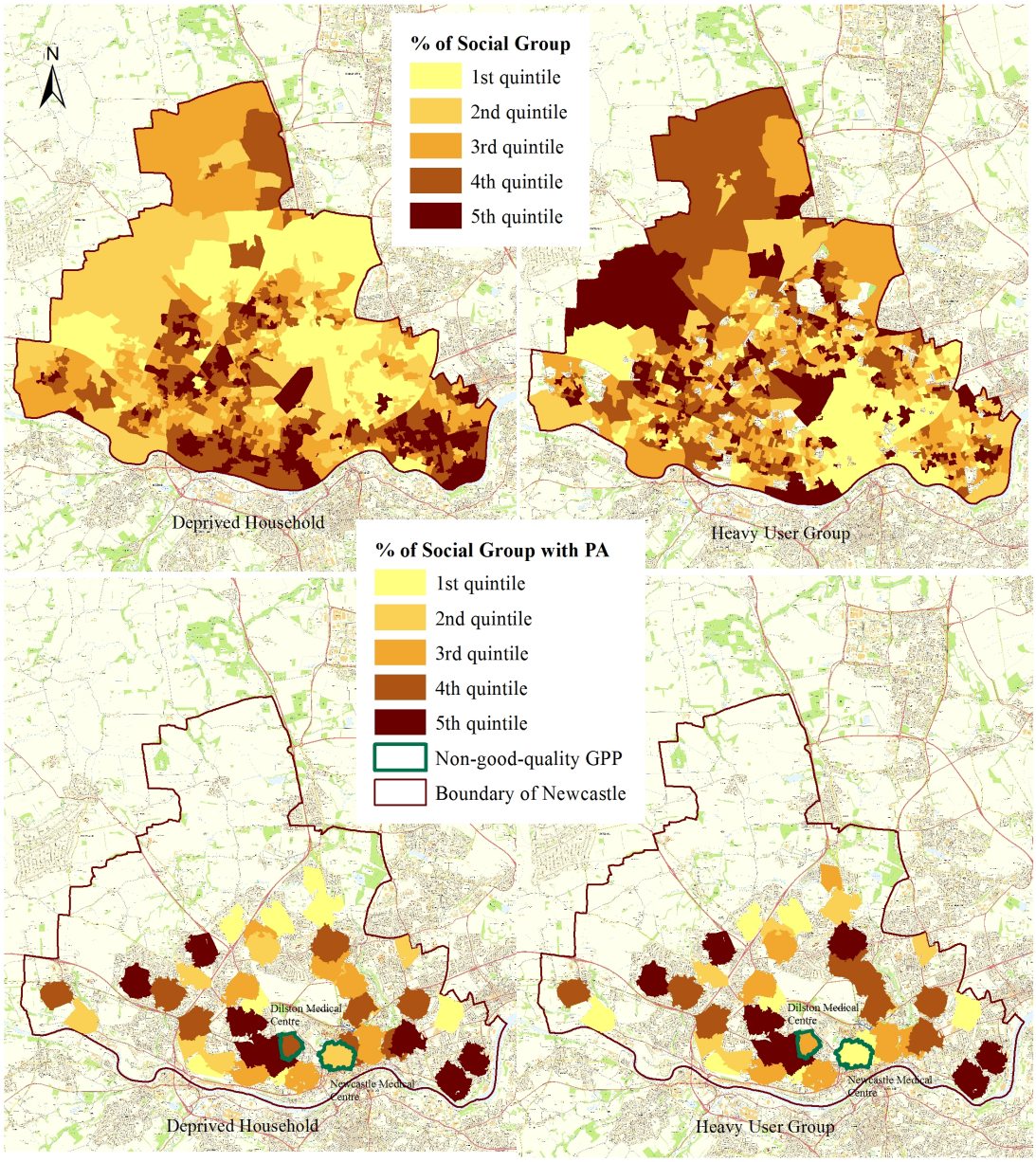
As can be seen from Table 24, the result from the spatial equity assessment of all GP practices in Newcastle based on the *equality* and *need* conceptions (i.e. *Need-based Equal Access*) is different from the result from the spatial equity assessment of all GP practices in the city based on the *equality* and *demand* conceptions (i.e. *Demand-based Inequitable Access*). This indicates a necessity of including the *demand* conception in the spatial equity assessment framework in addition to the *equality* and *need* conceptions. Because even though there could be an equal access to all healthcare services for the disadvantaged social group classified by an indicator reflecting needs in a city, there could be an inequitable access to all healthcare services for the disadvantaged social group classified by an indicator reflecting demands in the city.

Besides, the result from the spatial equity assessment of all GP practices in Newcastle i.e. *Need-based Equal Access*) is different from the result from the spatial equity assessment of GP practices of good quality in the city (i.e. *Need-based Inequitable Access*) based on the *equality* and *need* conceptions. This indicates a necessity of integrating the quality of

healthcare services into the spatial equity assessment framework. Because even though there could be an equal access to all healthcare services for the disadvantaged social group classified by an indicator reflecting needs in a city, there could be an inequitable access to healthcare services of good quality for the same disadvantaged social group in the city.

To visualize the distribution of social groups with potential access to all GP practices and GP practices of good quality in Newcastle, a GIS map (Map 20) was produced based on the percentages of social groups in the city and the percentages of social groups with potential access to each of all the 44 GP practices and the 42 GP practices of good quality by Service Area in the city on the city scale.

Map 20 Comparisons between the Percentage of Social Groups in Newcastle and the Percentages of Social Groups with Potential Access (PA) to all GP Practices (GPPs) and GPPs of Good Quality by Service Area in the City on the City Scale



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The deprivation data is the 2011 Census Data downloaded from the Infuse (2016).
The age data is the 2011 Census Data downloaded from the Infuse (2017).

Map 19 visualizes the distribution of the percentages of the disadvantaged social groups (the Deprived Household and the Heavy User Group) and the percentages of their potential access to all GP practices and GP practices of good quality by Service Area in Newcastle on the city scale. The darker the color the higher the percentages of the social groups in the city on the top two maps and the higher the percentages of the social groups with potential access to GP practices in the city on the bottom two maps. Out of the 44

GP practices in Newcastle, there are 42 GP practices with good quality (combining the 'Good' and 'Outstanding' CQC ratings; see Chapter Four for details). There are two GP practices with Service Areas highlighted in green that are counted as non-good-quality GP practices, i.e. Dilston Medical Centre with 'Requires Improvement' CQC rating and Newcastle Medical Centre with 'Inadequate' CQC rating.

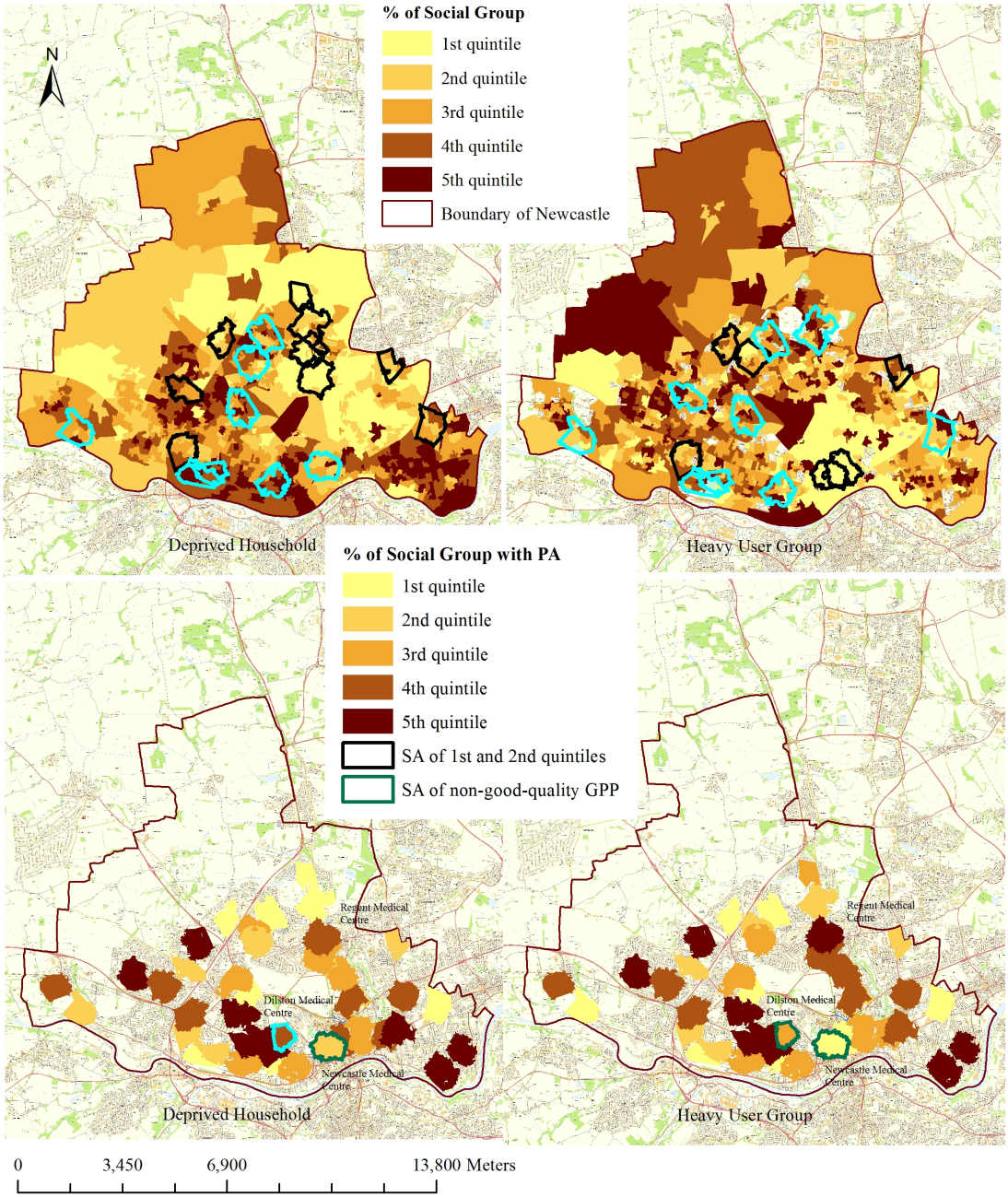
As can be seen from comparing the two maps on the left, the concentration of the higher percentages (i.e. the 4th and 5th quintiles) of the Deprived Household in Newcastle roughly matches and the higher percentages (i.e. the 4th and 5th quintiles) of the Deprived Household with potential access to all GP practices in the city. This echoes to the result of the assessment of the *equality* and *need* conceptions of spatial equity, a *need-based equal access*. In order to achieve a *need-based equitable access* based on the conceptual framework of spatial equity, it is suggested that the provision of GP services should be increased in both size and quality by comparing the percentages of the Deprived Household in the city and the percentages of the Deprived Household with potential access to all GP practices and GP practices of good quality in the city on the city scale. To be more specific, in terms of size, it is suggested to increase the size of GP practices (using FTE GPs as indicator) in areas with higher percentages of the Deprived Household (i.e. the 4th and 5th quintiles) while with lower percentages of the Deprived Household with potential access (i.e. the 1st and 2nd quintiles). In terms of quality, it is suggested to improve the quality of GP practices with higher percentages of the Deprived Household with potential access (i.e. the 4th and 5th quintiles) in the city on the city scale.

As can be seen from comparing the two maps on the right, the concentration of the higher percentages (the 4th and 5th quintiles) of the Heavy User Group in Newcastle does not match the higher percentages (the 4th and 5th quintiles) of the Heavy User Group with potential access to all GP practices in the city in general. This is in accordance to the result of the assessment of the *equality* and *demand* conceptions of spatial equity, a *demand-based inequitable access*. In order to achieve a *demand-based equitable access* based on the conceptual framework of spatial equity, it is suggested that the provision of GP services should be increased in both size and quality by comparing the percentages of the Heavy User Group in the city and the percentages of the Heavy User Group with potential access to all GP practices and GP practices of good quality in the city on the city scale. To be more specific, in terms of size, it is suggested to increase the size of GP practices (using FTE GPs as indicator) in areas with higher percentages of the Heavy

User Group (i.e. the 4th and 5th quintiles) while with lower percentages of the Heavy User Group with potential access (i.e. the 1st and 2nd quintiles). In terms of quality, it is suggested to improve the quality of GP practices with higher percentages of the Heavy User Group with potential access (i.e. the 4th and 5th quintiles) in the city on the city scale.

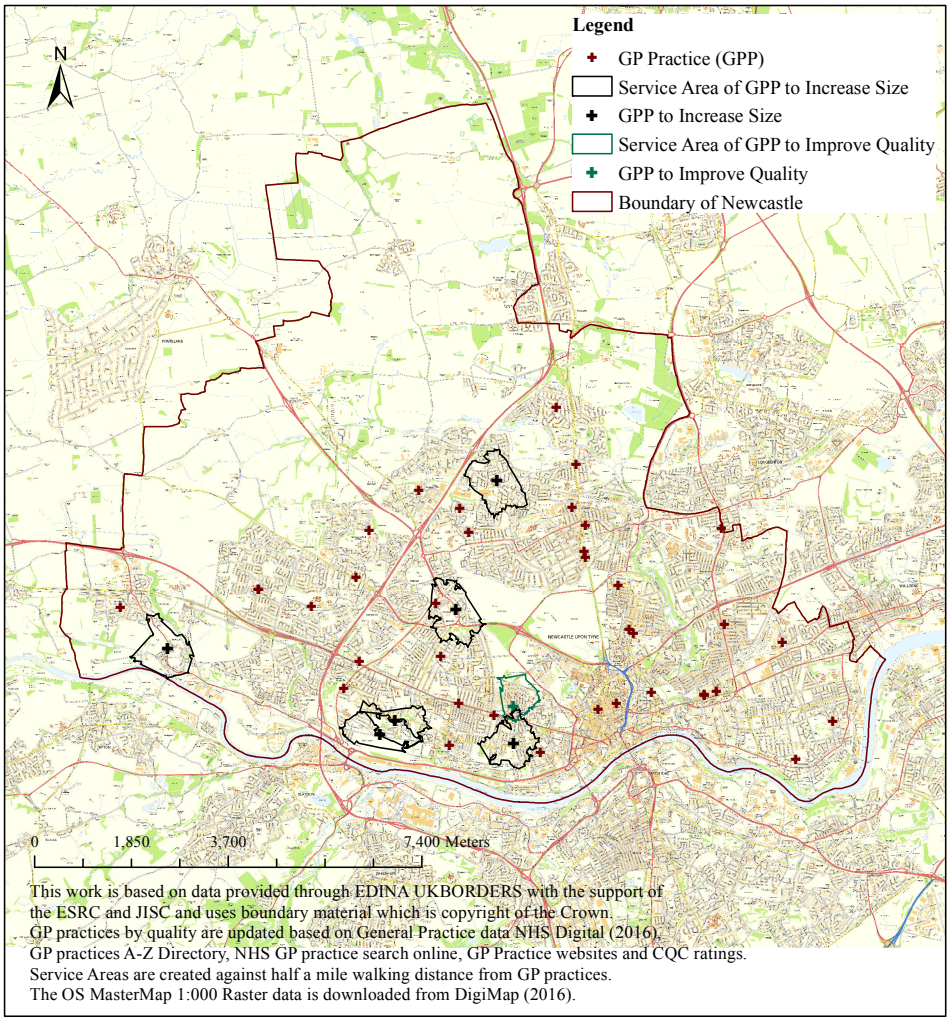
Therefore, based on the above assessment of both the *equality*, *need* and *demand* conceptions of spatial equity in Newcastle on the city scale, in order to increase equitable access to GP practices in the city, it is suggested to do the following: i) increase the size of GP practices in areas with higher percentages of the Deprived Household and Heavy User Group (i.e. 4th and 5th quintiles) while with lower percentages of the Deprived Household and Heavy User Group with potential access (i.e. 1st and 2nd quintiles); and ii) improve the quality of GP practices with higher percentages of the Deprived Household and Heavy User Group with potential access (i.e. the 4th and 5th quintiles) on the city scale. The selection of GP practices whose sizes and/or qualities are suggested to be increased and/or improved based on the result of spatial equity assessment can be achieved by the following six steps. The selection process will be illustrated using Map 21 and 22.

Map 21 Visualization of the Selection Process of GP Practices Whose Sizes and/or Qualities May Need to Increase and/or Improve in Newcastle on the City Scale



This work is based on data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown.
The deprivation data is the 2011 Census Data downloaded from the Infuse (2016).
The age data is the 2011 Census Data downloaded from the Infuse (2017).
GPP stands for GP practice; SA stands for Service Area. PA stands for Potential Access.

Map 22 Visualization of GP Practices (GPPs) Whose Sizes and/or Qualities May Need to Increase and/or Improve in Newcastle on the City Scale



The following are the six steps for selecting GP practices whose sizes and/or qualities are suggested to be increased and/or improved based on the result of spatial equity assessment in Newcastle on the city scale. First, select the Service Areas of the 1st and 2nd quintiles of the percentages of potential access for the Deprived Household and the Heavy User Group respectively from the bottom two maps of Map 21. Second, copy the selected two sets of Service Areas and paste them to the top two maps of Map 21 visualizing the percentages of the Deprived Household and the Heavy User Group respectively in Newcastle (Service Areas in black). Third, use the two sets of the selected Service Areas to identify areas with the 4th and 5th quintiles of the percentages of the Deprived Household and Heavy User Group in the city respectively (Service Areas highlighted on the top two maps of Map 21). Fourth, compare the top two maps of Map 21 to identify the identical highlighted Service Areas of GP practices whose sizes are suggested to be increased. Fifth, use the two Service Areas of non-good quality GP practices (in peacock

green in Map 21) to identify Service Areas of GP practices whose qualities are suggested to be improved. This was achieved by selecting the Service Areas of non-good quality GP practices with the 4th and 5th quintiles of the percentages of the Deprived Household and Heavy User Group with potential access respectively. The identical Service Areas of non-good quality of GP practices would be the ones that may need to improve quality. Sixth, use the selected Service Areas of GP practices whose sizes are suggested to be increased (identical highlighted Service Areas on the two top maps in map 21) and the Service Area of the GP practice whose quality is suggested to be improved (the highlighted Service Area on the bottom left hand side map in map 21) to clip all the 44 GP practices in Newcastle respectively to identify the GP practice(s) whose sizes are suggested to be increased (in back in map 22) and the GP practice whose quality is suggested to be improved (in peacock green in map 22) in Newcastle on the city scale.

The previous sections illustrated how to assess spatial equity by comparing the percentages of the two related social groups with potential access integrate quality applying the more accurate potential access measurement method – the HSW method. The following section will focus on summarizing the whole process from how to measure potential accessibility integrating size to assess spatial equity integrating quality at the household level on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) applying the HSW method. The Spatial Equity Assessment Framework will be developed based on the summary. Also summarized will be how to apply the assessment framework to provide policy recommendations on which healthcare services may need to increase size and/or improve quality for cities on the city scale.

7.5 The GIS-based Spatial Equity Assessment Framework and the Use of the Result from Spatial Equity Assessment Applying the Assessment Framework to Provide Policy Recommendations

7.5.1 The GIS-based Spatial Equity Assessment Framework

This section will emphasize the development of the GIS-based Spatial Equity Assessment Framework and how to apply the assessment framework for cities on the city scale to provide policy recommendations based on the result of spatial equity assessment. The Spatial Equity Assessment Framework contains four main steps, which includes Service Area creation, weights assigning to Output Areas with access, potential accessibility and potential access measurement, and spatial equity assessment. As the assessment

framework has potential to extend from healthcare services to other services, it will be presented in a generic way in this section.

Step One - Service Area creation. Creating Service Areas for a certain type of services individually using GIS-based Network Analysis (road and urban path networks) against the maximum walking distance threshold in a city on the city scale.

Step Two - Weights assigning to Census Units with access. Creating the overlap of the Service Areas and the lowest available census units in the city to calculate the number of Household Spaces located within the overlap, and then calculate the weight for each census unit with access by dividing the number of Household Spaces located inside the overlap by the number of Household Spaces located inside the Census Unit that the Service Areas are overlapped with using the following equation.

$$\boldsymbol{W_i} = \frac{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \left\{ \boldsymbol{B_{SA_j}} \cap \boldsymbol{B_{CU_i}} \right\}}{\sum_{i=1}^{n} \boldsymbol{N_{HS}} \in \boldsymbol{B_{CU_i}}} \qquad \textbf{Equation 8}$$

Where,

$\boldsymbol{W_i}$ = Weight of Output Area *i* with access

$\boldsymbol{N_{HS}}$ = The number of Household Spaces

$\boldsymbol{B_{SA_j}}$ = The boundary of Service Area *j*

$\boldsymbol{B_{CU_i}}$ = The boundary of the lowest available Census Unit *i*

For a Census Unit with no Household Space located inside Service Areas, the weight is '0'; for a Census Unit with all Household Spaces located inside Service Areas, the weight is '1'; for a Census Unit with parts of Household Spaces located inside Service Areas, the weight is '0-1'.

Step Three - Potential accessibility and potential access measurement. Joining the 2011 Census Data of social groups (i.e. population or household classified indicators reflecting needs and demands) to calculate the number of each social group with potential accessibility using the following equation.

$$\boldsymbol{N_{PAB_c}} = \sum_{j=1}^{m} \boldsymbol{N_{SG_j}}, \quad \boldsymbol{N_{SG_j}} = \sum_{i=1}^{n} (\boldsymbol{N_{SG_i}} \boldsymbol{W_i}) \qquad \textbf{Equation 9}$$

Where,

$\boldsymbol{N_{PAB_c}}$ = The number of Potential Accessibility in a city

$\boldsymbol{N_{SG_j}}$ = The number of each Social Group in Service Area *j*

$\boldsymbol{N_{SG_i}}$ = The number of each Social Group in Census Unit *i*

$\boldsymbol{W_i}$ = The weight of Census Unit *i* with access

Then, calculating the percentage of each social group with potential accessibility in each Service Area by dividing the number of each social group with potential accessibility (the numerator) by the total number of each social group involved in the calculation of the numerator in the city on the city scale taking into account the overlay of Service Areas (the denominator) using the following equation.

$$\boldsymbol{P_{PAB_c} = \sum_{i=1}^{m} P_{PAB_j}}\ ,\ \boldsymbol{P_{PAB_j} = \frac{N_{SGPAB_j}}{N_{SG_c}}} \qquad \textbf{Equation 10}$$

Where,

$\boldsymbol{P_{PAB_c}}$ = The percentage of Potential Accessibility in the city

$\boldsymbol{P_{PAB_j}}$ = The percentage of Potential Accessibility in Service Area *j*

$\boldsymbol{N_{SGPAB_j}}$ = The number of each Social Group with Potential Accessibility in Service Area *j*

$\boldsymbol{N_{SG_c}}$ = The total number of each Social Group involved in the calculation of the number of Potential Accessibility in the city on the city scale taking into account the overlay of Service Areas

After that, calculating the percentage of potential access to services for each social group by multiplying the percentage of each social group with potential accessibility by the size weighting of each service in the city on the city scale using the following equation (classifying the result of the percentage of each social group with potential accessibility into quintiles).

$$\boldsymbol{P_{PA_c} = \sum_{j=1}^{m} P_{PA_j}}\ ,\ \boldsymbol{P_{PA_j} = P_{PAB_j}\left(S_{S_j}/S_{S_c}\right)} \qquad \textbf{Equation 11}$$

Where,

$\boldsymbol{P_{PA_c}}$ = The percentage of Potential Access in the city

$\boldsymbol{P_{PA_j}}$ = The percentage of Potential Access in Service Area *j*

$\boldsymbol{P_{PAB_j}}$ = The percentage of Potential Accessibility in Service Area *j*

$\boldsymbol{S_{S_j}}$ = The Size of Service *j*

$\boldsymbol{S_{S_c}}$ = The total Size of the Services in the city

Step Four - Spatial equity assessment. Assessing spatial equity in a city on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). For assessing the *equality* and *need* conceptions, the percentages of the disadvantaged social group and advantaged social group classified by an indicator reflecting needs with potential access to all services and services of good quality in the city are compared on the city scale. For assessing the *equality* and *demand* conceptions, the percentages of the disadvantaged social group and advantaged social group classified by an indicator reflecting demands with potential access to all services and services of good quality in the city are compared on the city scale.

For the assessment of the *equality* and *need* conceptions of spatial equity, a *need-based equitable access* would be suggested when the percentage of the disadvantaged social group is significantly higher than the percentage of the advantaged social group classified by an indicator reflecting needs with potential access to all services and services of good quality in a city on the city scale; a *need-based equal access* would be suggested when the percentage of the disadvantaged social group is higher than the percentage of the advantaged social group classified by an indicator reflecting needs with potential access to all services and services of good quality in a city on the city scale while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *need-based inequitable access* would be suggested when the percentage of the disadvantaged social group is lower than the percentage of the advantaged social group classified by an indicator reflecting needs with potential access to all services and services of good quality in a city on the city scale.

For the assessment of the *equality* and *demand* conceptions of spatial equity, a *demand-based equitable access* would be suggested when the percentage of the disadvantaged social group is significantly higher than the percentage of the advantaged social group classified by an indicator reflecting demands with potential access to all services and services of good quality in a city on the city scale; a *demand-based equal access* would be suggested when the percentage of the disadvantaged social group is higher than the percentage of the advantaged social group classified by an indicator reflecting demands with potential access to all services and services of good quality in a city on the city scale while the difference is not significant and the result of the effect size calculation is '0' (or less than 0.2, i.e. Small); a *demand-based inequitable access* would be suggested when the percentage of the disadvantaged social group is lower than the percentage of the

advantaged social group classified by an indicator reflecting demands with potential access to all services and services of good quality in a city on the city scale.

The SPSS Mann-Whitney U is performed to test the difference when the percentage of the disadvantaged social group is higher than the percentage of the advantaged social group classified by an indicator reflecting needs or demands with potential access to all services or services of good quality in a city on the city scale. The median values of the percentages of two groups under comparison are compared to determine whether there would be an equitable, equal or inequitable access to services as SPSS Mann-Whitney U tests only report results in a two-tailed manner. The Mann-Whitney U only tests the significance of the difference, which may be not enough for it only examines the likeability of the findings are due to chance, so the effect size was calculated applying Cohen's Effect Size Index to understand the magnitude of differences. The combination of statistical significance and effect size can help understand the full impact of a study (Sullivan and Feinn, 2012).

7.5.2 The Use of the Result from the Application of the GIS-based Spatial Equity Assessment Framework to Provide Policy Recommendations for Cities on the City Scale

This section will summarize how to use the result from the application of the GIS-based Spatial Equity Assessment Framework to provide policy recommendations on which services may need to increase size and/or improve quality for cities on the city scale. The summary will be presented in a generic way as the assessment framework has potential to extend from healthcare services to other services.

There are five steps involved in the selection process of which services may need to increase size and/or improve quality for cities on the city scale based on the result from spatial equity assessment applying the assessment framework. First, select the Service Areas with the 1st and 2nd quintiles of the percentages of potential access for the disadvantaged social groups classified by indicators reflecting needs and demands respectively in a city on the city scale. Second, use the two sets of the selected Service Areas to identify areas with the 4th and 5th quintiles of the percentages of the disadvantaged social groups classified by indicators reflecting needs and demands respectively in the city. Third, compare the identified areas to find identical Service Areas of services whose sizes are suggested to be increased. Fourth, Select Service Areas of non-good quality services with the 4th and 5th quintiles of the percentages of the

disadvantaged social groups classified by indicators reflecting needs and demands with potential access respectively in a city. Fifth, find identical Service Areas of non-good quality services whose qualities are suggested to be improved in the city on the city scale.

7.6 Summary

In this chapter, the illustration was provided on how to assess spatial equity based on the comparison between the percentages of the advantaged and disadvantaged social group with potential access (potential accessibility integrating size) to healthcare services integrating quality based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions) using GP practices in Newcastle as a case study. As the HSW method has been demonstrated as more accurate than the PWC method in potential access measurement, the percentages of social groups with potential access to GP practices in the city calculated applying the HSW method in the previous chapter were used for the illustration in this chapter.

The chapter emphasized the following four aspects: i) illustrating the application of the *equality*, *need* and *demand* conceptions of spatial equity by comparing the percentages of the disadvantaged and advantaged social groups with potential access to GP practices in Newcastle; ii) illustrating how to integrate the quality of GP practices into the assessment of the *equality*, *need* and *demand* conceptions of spatial equity; iii) analyzing the findings from the spatial equity assessment of GP practices in Newcastle, and illustrating how to make policy recommendations on which GP practices that may need to increase size or improve quality based on the result of the spatial equity assessment for the city on the city scale; and iv) developing the GIS-based Spatial Equity Assessment Framework and summarizing how to provide policy recommendations for cities on the city scale.

The chapter concludes data analysis of this research. In the two data analysis chapters, first, the HSW technique has been demonstrated as more accurate than the PWC technique in population estimation inside Service Areas as well as potential accessibility and potential access measurement. Second, spatial equity assessment integrating quality has been illustrated using the more accurate potential access measurement method – the HSW method. Third, the four-step GIS-based Spatial Equity Assessment Framework has been developed. Fourth, an illustration of how to provide policy recommendations has been provided using the result of spatial equity assessment applying the assessment framework for cities on the city scale. The two data analysis chapters form a basis for the final chapter of the thesis – the Conclusions Chapter.

Chapter Eight: Conclusions

8.1 Introduction

The just distribution of services is a significant and challenging goal for planners and policy makers (Talen, 1998). It is faced with the generic problem of the continuous distribution (sometimes uneven though) of populations throughout a city and the distribution of services located at discrete point locations (Hewko et al. 2002; Knox, 1978). In assessing access to services, geographical analysis of spatial equity requires measurement, where the conclusions of spatial equity assessment will be sensitive to how this measurement is conceptualized and calculated (Talen, 2003; Talen and Anselin, 1998).

However, reviewing the literature reveals that there is a lack of comprehensive and accurate GIS-based spatial equity assessment framework, which would be in accordance with a recognized conceptual framework of spatial equity, such as Lucy (1981) and Talen's (1998) conceptualization and conceptions of *equity* and Omer's (2006) definition on *spatial equity*. Thus, there is a need to explore how to develop a more comprehensive and accurate GIS-based Spatial Equity Assessment Framework.

To achieve this, it is necessary to answer the following three research questions. How to disaggregate the lowest available census data to the household level using GIS? How to measure accessibility to healthcare services integrating the size of the services (i.e. potential access) for social groups at the household level on the city scale? How to assess spatial equity of healthcare services integrating the quality of the services for cities on the city scale based on the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions)?

Despite frequent references to 'equitable access to health care' either in research or policy, little agreement has been reached in the health and healthcare-related literature on its specific meaning; the absence of a commonly accepted interpretation of equitable access to healthcare services has caused problems such as inconsistency in healthcare policies (Oliver and Mossialos, 2004). Although there has been a longstanding goal to investigate the opportunities available to populations in healthcare services and medical geography research (Delamater, 2013), due to resource constraints, it is necessary to set priorities in healthcare provision so as to help make sure that more healthcare services can be provided to residents and social groups with greater healthcare needs and

demands. To this end, it is necessary to answer the fourth research question - How to apply the GIS-based Spatial Equity Assessment Framework to provide policy recommendations for cities on the city scale?

Concerning the conceptual framework of spatial equity, apart from the *equality* and *need* conceptions, the *demand* conception was incorporated into conceptual framework to assess spatial equity drawing upon existing studies (i.e. Lucy, 1981; Omer, 2006; Talen, 1998). It is based heavily on Lucy (1981) and Talen's (1998) conceptualization and conceptions of *equity* and Omer's (2006) definition on *spatial equity*. For the integrating of size into access measurement, the size weighting was introduced to the process of the measurement of potential accessibility (i.e. potential access) of healthcare services. The size weighting is calculated by dividing the number of Full Time Equivalent (FTE) physicians (an indicator used to measure availability, such as FTE GPs) in each healthcare service provision location by the total number of FTE physicians in a city. To integrate the quality into spatial equity assessment framework when assessing spatial equity, healthcare services in a city were classified into two categories for analysis, i.e. all healthcare services in a city and healthcare services of good quality that are selected according to related quality criteria in the city. Spatial equity is not only assessed by comparing the percentages of the disadvantaged and advantaged social groups with potential access to all healthcare services but also to healthcare services of good quality in a city on the city scale.

To further reduce the aggregation error, an alternative technique, the HSW technique to the PWC technique was developed and adopted by cleaning and using the most accurate cadastral and address-based data, such as the UKBuildings data and the OS AddressBase Premium data. The cleaned datasets were used as ancillary data of the HSW technique to disaggregate census data from the Output Area level to the household level. The disaggregated data was then used to measure potential accessibility and potential access in a more accurate way. Spatial equity was assessed based on the result of potential access measurement on the city scale.

In order to illustrate how to achieve the above empirically, GP practices in Newcastle were used as a case study. After the illustration, the following calculation processes were summarized, including how to measure potential accessibility integrating size (i.e. potential access) and how to assess spatial equity integrating quality at the household level on the city scale applying the HSW method. The summary led to the development

of the four-step GIS-based Spatial Equity Assessment Framework which is the aim of this research. The research also summarized five steps to use the result from spatial equity assessment to provide policy recommendations for cities on the city scale.

8.2 Research Findings and Importance to the Existing Studies

8.2.1 A Population Access Technique to Measuring Potential Accessibility and Potential Access at the Household Level on the City Scale

Drawing upon Nicholl's (2001) research, the PWC technique was applied to make population estimation inside Service Areas and measure potential accessibility and potential access on the city scale. However, the population weighted centroid is a single summary reference point of census unit such as the Output Area (ONS Website, 2016). Although the use of population weighted centroids provides more accurate representation of census units than geographic centroids, thus reducing aggregation errors when applying the *Have Their Centre In* criterion to measure potential accessibility, the PWC technique is still a place access rather than population access measurement method.

The PWC technique assigns the weight of '1' to census units with their centroids located inside Service Areas and the weight of '0' to census units with their centroids located outside Service Areas, and then calculates and sums up associated populations. In other words, the PWC technique only divides Output Areas into two categories in population estimation and potential accessibility measurement: i) the Output Area with full access when the population weighted centroid of the Output Area is located inside the Service Area even though not all households within the Output Area are located inside the Service Area; and ii) the Output Area with no access when the population weighted centroid of the Output Area is located outside the Service Area even though a part of households within the Output Area are located inside the Service Area.

The use of the population weighted centroids and the weight of either '1' or '0' assigned to Output Areas here are a source of aggregation errors. Because it is not likely that the population within census units locate either inside or outside Service Areas, rather they locate fully or partially inside Service Areas or outside Service Areas due to the uneven distribution and the heterogeneity of the physical environment within census units. Thus, it requires the identification of a more accurate spatial disaggregation technique that can be used to disaggregate the lowest level census units available to the household level in order to increase the accuracy by taking account of the population within census units that locate partially inside Service Areas.

In reality, with the updating of more accurate cadastral data such as the OS AddressBase Premium data and address-based data such as the UKBuildings data in the UK context, there could be an alternative technique to be used to further improve the accuracy in population estimation and further reduce aggregation errors by replacing the use of population weighted centroids to represent census units. For this, this research proposes a cadastral and address-based population weighting technique, the Household Space Weighting (HSW) technique to disaggregate census data to the household level to estimate population and measure access in a more accurate way.

The HSW technique is a cadastral and address-based population weighting technique for population estimation and population access measurement method, which disaggregates census data from the Output Area level to the household level using the OS AddressBase Premium data and the UKBuildings data as its ancillary data. The technique does not use areal weighting or the binary technique to estimate population, which neither requires remotely sensed land cover/land use data to estimate population density classes. These have been demonstrated in Maantay et al.'s (2007) research as more advantageous compared to other dasymetric mapping techniques including the Filtered Areal Weighting techniques in terms of disaggregating data and making population estimation inside Service Areas. Instead, the HSW technique takes into account different dwelling types and multiple occupancy counts of residential buildings in use (e.g. Household Spaces).

In contrast to how weights are assigned to census units with access applying the PWC technique (either '1' or '0'), the HSW technique calculates the number of Household Spaces (to represent the number of households) and assigns weights to the lowest level census units available according to the proportion of Household Spaces within the census units located inside Service Areas. This means that the HSW technique assigns the weight of '1' to the census units with all Household Spaces located inside Service Areas, assigns the weight of '0-1' to the census units with partial Household Spaces located inside Service Areas, and assigns the weight of '0' to the census units with no Household Space located inside Service Areas. In other words, the HSW technique divides Output Areas into three categories in population estimation and potential accessibility measurement: i) the Output Area with full access when all households (using Household Space data to represent) within the Output Area are located within the Service Area; ii) the Output Area with partial access when parts of households within the Output Area are located inside the

Service Area; and iii) the Output Area with no access when no household within the Output Area is located inside the Service Area.

The different categorization of access between the HSW and PWC techniques results in some Output Areas with population weighted centroids located inside Service Areas (meaning with full access) applying the PWC method, while there are only parts of Household Spaces located inside the Service Areas (meaning with partial access) applying the HSW method; there are some Output Areas with no population weighted centroids located inside Service Areas (meaning with no access) applying the PWC method, while there are still parts of Household Spaces located inside the Service Area (meaning with partial access) applying the HSW method. In other words, Output Areas involved in population estimation and the calculation of potential accessibly are signed with weights between '0' and '1' when applying the HSW technique rather than '0' or '1' when applying the PWC technique. This is the source of aggregation errors caused by the application of the PWC technique.

Geographic analysis of the case study indicates that the HSW technique is closer to reality because it is not likely that all residents or households either located inside or outside Service Areas. Rather they locate fully or partially inside Service Areas or outside Service Areas. Statistical analysis shows that the PWC technique produces inaccurate population estimation for 267 Output Areas (910 in total in the city) due to its dichotomous categorization of census units either fully located inside or outside Service Areas. When applying the two techniques to measure potential access to all GP practices in Newcastle taking into account the overlay of Service Areas, there are differences in the percentages of social groups with potential accessibility at the Service Area scale. This could have policy implications if services that are less accessible by the disadvantaged social group would be selected to increase the level of access. On the city scale, even though the differences in the numbers of potential accessibility are small, the differences in the percentages of potential accessibility and potential access are large. The percent increase in the percentage of social groups with potential accessibility applying the PWC method to the HSW method is up to 21%, and the figure for potential access is up to 22% in Newcastle on the city scale.

This is crucial because it is the percentages of potential access (the percentage of potential accessibility multiplying by the size weighting) rather the number of potential accessibility that is used to assess spatial equity because of the difference in population

size of each social group in a city as the size of each social group is different in the city. The large differences suggest that if service planners or policy makers would like to measure access to services for social groups in their cities, it would be good to use a more accurate method, or at least be aware of the implications of using the PWC technique.

Based on the conceptual, statistical and geographical illustrations of and comparisons between the application of the HSW and PWC techniques using GP practices in Newcastle as a case study, the research has demonstrated that the HSW technique is more accurate than the PWC technique in population estimation inside Service Areas as well as potential accessibility and potential access measurement. Because the HSW technique is closer to reality and reduces aggregation errors by taking into consideration Houses in Multiple Occupancy of residential buildings by dwelling type in use and estimating population inside Service Areas including partial access apart from full and no access compared to the application of the PWC technique.

8.2.2 A More Comprehensive Typology and Measurement of Access on the City Scale Involving the Overlay of Service Areas in the Calculation Process

This research measures *pedestrian-oriented access* (a type of access measured for locally oriented populations, such as the elderly, the disabled and the poor, who rely on modes of transport other than the automobile) rather than *automobile-oriented access* (a type of access measured for populations with private cars or public transport as modes of transport) (Talen, 2003). Despite the importance particularly in measuring access for certain social groups, there has been little discussion on *pedestrian-oriented access* in the existing research (Khan, 1992; Talent, 2003). The emphasis of the existing research is disproportionally placed on *automobile-oriented access* rather than *pedestrian-oriented access* to healthcare services (only a few, e.g. Todd *et al*., 2014; 2015). Thus, this research adds discussions on *pedestrian-oriented access* to the existing studies.

Spatial equity assessment in this research was undertaken at different scales, e.g. the Service Area scale and the city scale, as it is assessed based on the comparison between the percentage of the disadvantaged and advantaged social groups (population classified by needs and demands) with potential access. The calculation at the two scales is related to the necessity of involving the overlay of Service Areas in the measurement processes, which draws upon Luo and Wang's (2003) research illustrating how to take into account the overlay of Catchment Areas (Service Areas) in calculating the physician-to-population ratios to measure potential access applying the 2SFCA method.

To be more specific, besides the integration of the size of healthcare services into potential access measurement at the Service Area scale, the calculation of the percentage of access on the city scale requires the involvement of the overlay of Service Areas in the calculation processes. Because apart from the size of GP practices, whether social groups located inside the overlay of Service Areas or inside only one Service Area can also affect the level of potential access. Social groups located inside the overlay of Service Areas have higher level of access compared to those who located inside only one of the Service Areas (Luo and Wang, 2003). An example comparing the level of access calculated based on two individual Service Areas and the overlaid Service Area of the same two Service Areas of two GP practices in Newcastle demonstrated Luo and Wang' (2003) argument. Thus, this research adds to the discussion on involving the overlay of Service Areas in access measurement for cities on the city scale.

8.2.3 A More Comprehensive Spatial Equity Assessment Framework and the Use of the Result from Spatial Equity Assessment Applying the Assessment Framework to Provide Policy Recommendations

The research develops a more comprehensive spatial equity assessment framework because it integrates the *demand* conception and quality into the assessment framework and incorporates the *equality* conception into the *need* and *demand* conceptions. It starts from identifying a conceptual framework of spatial equity for assessing spatial equity drawing on Lucy (1981) and Talen's (1998) conceptualization and conceptions of *equity* and Omer's (2006) definition on *spatial equity*. As the existing studies disproportionately focus on measuring access reflecting the *equality* and/or *need* conception(s) (e.g. Boone, *et al*.; Chang and Liao, 2011; Comber *et al*., 2008; Khan (1992); Macedo and Haddad, 2015; Nicholls, 2001; Omer, 2006; Talen and Anselin, 1998), the ignorance of the *demand* conception can lead to partial results in spatial equity assessment, this research includes the *demand* conception in the conceptual framework of spatial equity.

The necessity of including the *demand* conception in the assessment framework has been justified in the case study of this research as the spatial equity assessment of all GP practices in Newcastle based on the *equality* and *need* conceptions (*need-based equal access*) is different from the result from the spatial equity assessment of all GP practices in the city based on the *equality* and *demand* conceptions (*demand-based inequitable access*). This means that even though there could be an equal access to all healthcare services for the disadvantaged social group classified by an indicator reflecting needs in a

city, there could be an inequitable access to all healthcare services for the disadvantaged social group classified by an indicator reflecting demands in the city.

The research incorporates the *equality* conception into the *need* and *demand* conceptions drawing upon Nicholls' (2001) research. This helps overcome the conflicting problems between the former and the latter caused by the impossibility to locate services equidistant to potential users due to physical limitation (Lucy, 1981). With a certain distance threshold, *equality* is assessed in the form of *need-based equal access* and *demand-based equal access*.

Although quality of services was identified as one of main dimensions or variables of accessibility (e.g. Peters et al. 2008; Shengelia et al., 2003; Talen, 1998), little research has been conducted on how to integrate quality into spatial equity assessment. This research illustrates how quality can be integrated into spatial equity assessment. The necessity of integrating the quality of healthcare services into the spatial equity assessment framework has been justified in the case study of this research as the result from the spatial equity assessment of all GP practices in Newcastle (*need-based equal access*) is different from the result from the spatial equity assessment of GP practices of good quality in the city (*need-based inequitable access*) based on the *equality* and *need* conceptions. This means that even though there could be an equal access to all healthcare services for the disadvantaged social group classified by an indicator reflecting needs in a city, there could be an inequitable access to healthcare services of good quality for the same disadvantaged social group in the city. Thus, the integration of the quality of services into the spatial equity assessment in this study is more comprehensive than the existing studies in this regard.

Moreover, the research presents the GIS-based Spatial Equity Assessment Framework in a generic way, as it has potential to extend from healthcare services to other services. It also illustrates how to use the result of spatial equity assessment applying the assessment framework to provide policy recommendations and summarizes five steps to achieve that in a generic way.

8.2.4 The Use of the Most Updated Data and Data Cleaning

Data cleaning is involved in the application of both the PWC and HSW techniques to calculate potential accessibility. The HSW technique requires data cleaning when residential buildings are selected to calculate the number of Household Spaces in a city in ArcGIS and the calculation of the numbers of residents and social groups in a city in

Excel that involves the overlay of Service Areas. Apart from the second step, the PWC technique requires data cleaning when calculating population weighted centroids of the lowest available census units in the city in ArcGIS. But if the population weighted centroids are available as in the case study of this research, the PWC technique only requires data cleaning in the second step.

The application of the PWC method could involve one step less in data cleaning. However, the data cleansing in the first step to select residential buildings from all buildings in a city using the OS AddressBase Premium data and the UKBuildings data and then calculating the number of Household Spaces is to disaggregate census data from the Output Area level to the household level on the city scale. In the case of the absence of the house level census data, this is a more accurate way to disaggregate census data to the household level. Since the application of the HSW method using this disaggregation technique has demonstrated as more accurate than the existing most accurate method taking into consideration the location of households (the PWC method) in the measurement of potential accessibility and potential access, it is worth spending time on this extra step of data cleaning.

8.3 Contributions of the Research

The research may contribute to better measuring potential accessibility and potential access and better assessing spatial equity of healthcare services in the following four aspects. First, the HSW technique, a cadastral and address-based population weighting technique, is proposed to be applied to disaggregate the lowest-level census data available to the household level in a city using ancillary data reflecting the number of Houses in Multiple Occupancy of residential buildings in use to represent the number of Households. In the case of the absence of the house level census data, this is a more accurate way to spatially disaggregate the lowest-level census data available to the household level as the exiting studies have not yet managed to disaggregate census data to such fine-grained level. The research argues for the use of the cadastral and address-based population weighting technique to replace the use of population weighted centroids to represent census units in access measurement, such as in the context of application of the *Have Their Centre In* criterion in the planning research field and 2SFCA methods in the health-related and medical geography research field.

Second, the research demonstrates the application of a more accurate integrated availability and accessibility approach - the HSW method to measure potential

accessibility and potential access in an absolute manner, and then to assess spatial equity in accordance with the conceptual framework of spatial equity (*equality*, *need* and *demand* conceptions). This leads to the development of a more comprehensive and accurate spatial equity assessment framework, the GIS-based Spatial Equity Assessment Framework. The assessment framework can be used to guide the measurement of potential accessibility integrating the size of healthcare services (i.e. potential access) in an absolute manner and the assessment of spatial equity integrating the quality of healthcare services for social groups at the household level on the city scale.

Third, the application of the assessment framework can help local councils measure potential accessibility and potential access in an even more accurate way as they may access individual level population data rather than household level population data as in this research. This can better inform service planners and policy makers of priorities that could be given to which healthcare services that may need increase size and/or improve quality in a more accurate way so as to help increase equitable access to those services. Fourth, the assessment framework can extend from measuring potential to realized access if it is used by local councils as they may access patient-level data. It can also extend from healthcare services to other services in terms of spatial equity assessment.

8.4 Limitations and Further Research

8.4.1 Limitations of the Research

There are several limitations of this research. First, there may be a small 'border effect' in this research as it does not include data on GP practices beyond but close to the administrative boundary of Newcastle. But the research focuses on measuring potential accessibility and potential access to and spatial equity of healthcare services for cities on the city scale. It is more methodological rather than empirical as the aim of the research is to develop a spatial equity assessment framework for guiding the measurement of potential access and spatial equity assessment on the city scale using GP practices in Newcastle as a case study.

This has two main implications. First, measuring potential access to and assessing spatial equity of GP practices in Newcastle are a means to an end, not an end in itself even though they are measured and assessed in a most precise way using the most accurate and updated datasets available. Second, on the city scale in this research means that the research considers a city as a platform, which means that the city within its administrative boundary is the study area rather the city and its surrounding areas.

Despite all of the above, the 'border effect' is still considered as a limitation from the empirical perspective. To overcome the limitation, some existing studies have proposed possible solutions to the 'edge effect'. For instance, Luo and Wang (2003) and Wan *et al*. (2012) have proposed to use a buffer zone near the boundaries of the study area to account for the 'edge effect' (e.g. a 60-minute buffer zone was identified for the borders of the study area in Wan *et al*.'s (2012) study). The distance for creating the buffer zone can be the same as the distance used for creating the Service Area performing the GIS Network Analyst (such as half a mile walking distance as in this research).

Second, due to the absence of individual level census data, the research uses the number of Household Spaces to represent the number of households for the calculations of potential accessibility and potential access when applying the HSW technique. The technique is not a limitation itself by using the number of Household Spaces to represent the number of households. The limitation could be that it is the household level rather than the individual level that it aggregates the data into. However, in the case of the absence of the house level census data, the problem should be small as the calculations involve population weighting using currently the most accurate cadastral and address-based data as its ancillary data at the household level taking into consideration different dwelling types and multiple occupancy counts of residential buildings in use to represent the Household Space. And the number of Household Spaces rather than the location of each Household Space is used to represent the number of households within the Service Area.

Third, the research only takes socio-spatial perspective to investigate access to healthcare services, which means it only adopts *availability* and *accessibility* out of the five dimensions of access (*availability*, *accessibility*, *accommodation*, *affordability* and *acceptability*). Aspatial dimensions of access that could be more quality are not included into the measurement. Spatial equity is assessed based on the results of access measurement. This is a limitation of this research and many other existing studies for not including aspatial factors into access measurement. Potential solutions could be taking a combined quantitative and qualitative approach to include both socio-spatial and aspatial perspectives.

Fourth, the research only focuses on potential access rather than realized access (or utilization) due to the unavailability/accessibility of patient-level GP utilization data. This may be worth further research when related data is available.

8.4.2 Further Research

There are three aspects that may deserve further research. The first aspect is to expand the research from potential access to realized spatial access (may use patient-level consultation rates data if the data is available) to healthcare services particularly GP practices of the same case study city (Newcastle) on the city scale, compare the association between the results of the potential access and realized spatial access, and assess spatial equity in accordance with the GIS-based Spatial Equity Assessment Framework. The result from the realized spatial access measurement and spatial equity assessment could be useful to further inform urban planners and policy makers of priorities that could be given to which GP practices may need to increase size and/or improve quality.

The second aspect is the association between mobility and access by urbanity/rurality particularly in cities where the level of access is much lower in rural areas compared to urban areas using half a mile as the maximum walking distance threshold. In that case, different threshold standards may need to be used for measuring potential access in rural areas according to population densities. Factors related to mobility, such as car ownership, the existence and frequency of public transport; and the implications of the establishment of satellite surgeries may also be worth further investigating.

The third aspect is to extend from healthcare services to other services and may use individual level big data to measure realized spatial access and then assess spatial equity applying the GIS-based Spatial Equity Assessment Framework.

References

Aday, L. and Anderson, R. (1974) A Framework for the Study of Access to Medical Care, *Health Services Research*, 9, pp.208-220.

Andersen, M. McCutcheon, A., Aday, L., Chiu, G. and Bell, R. (1983) Exploring Dimensions of Access to Medical Care, *Health Services Research*, 18(1), pp.49-74.

Andersen, R. (1995) Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? *Journal of Health and Social Behavior*, 36, pp.1-10.

Apparicio, P., Abdelmajid, M, Riva, M. and Shearmur, R. (2008) Comparing Alternative Approaches to Measuring the Geographical Accessibility of Urban Health Services: Distance Types and Aggregation-error Issues, *International Journal of Health Geographics*, 7(7).

Apparicio, P. and Seguin, A. (2006) Measuring the Accessibility of Services and Facilities for Residents of Public Housing in Montreal, *Urban Studies*, 43(1), pp.187-211.

Apparicio, P., Cloutier, M. and Shearmur, R. (2007) The Case of Montreal's Missing Food Deserts: Evaluation of Accessibility to Food Supermarkets, *International Journal of Health Geographics*, 6(1), PP.4.

Bice, T., Eichhorn, R. and Fox, P. (1972) Socioeconomic Status and Use of Physician Services: A Reconsideration, *Medical Care*, 10(3), pp.261-271.

Blaxter, M. (1984) Equity and Consultation Rates in General Practice, *British Medical Journal*, 288, pp.1963-1967.

Boone, C. (2008) Improving Resolution of Census Data in Metropolitan Areas Using A Dasymetric Approach: Applications for the Baltimore Ecosystem Study, *Cities and the Environment*, 1(1).

Boone, C., Buckley, G., Grove, M. and Sister, C. (2009) Parks and People: An Environmental Justice Inquiry in Baltimore, Maryland, *Annals of the Association of American Geographers*, 99(4), pp.767-787.

Boyle, S. (2008) The UK Health Care System. Available at: http://www.commonwealthfund.org/~/media/files/resources/2008/health-care-system-profiles/uk_country_profile_2008-pdf.pdf

[Accessed: 01/09/2016]

Care Quality Committee (2015) What We Do and How We Do It. Available from:

http://www.cqc.org.uk/content/who-we-are-and-what-we-do

[Accessed: 30/06/2016]

Carr-Hill, R., Rice, N. and Roland, M. (1986) Socio-economic Determinants of Rate of Consultation in General Practice based on Fourth National Morbidity Survey of General Practices, *British Medical Journal*, 312, pp.1008-1013.

Chang, H. and Liao, C. (2011) Exploring An Integrated Method for Measuring the Relative Spatial Equity in Public Facilities in the Context of Urban Parks, 28, pp.361-371.

Christie, S. and Fone, D. (2003) Equity of Access to Tertiary Hospitals in Wales: A Travel Time Analysis, *Journal of Public Health Medicine*, 25(4), pp.344-350.

Comber, A., Brunsdon, C. and Green, E. (2008) Using A GIS-based Network Analysis to Determine Urban Greenspace Accessibility for Different Ethnic and Religious Groups, *Landscape and Urban Planning, 86*(1), pp.103-114.

Crawford, T. (2006) Polygon-to-Polygon Spatial Accessibility Using Different Aggregation Approaches: A Case Study of National Forests in the US Mountain West Region, *Transactions in GIS*, 10(1), pp.121-140.

Cromley, E. and McLafferty, S. (2012) GIS and Public Health (2rd ed.). New York and London: The Gullford Press.

Daniels, N. (1982): Equity of Access to health care: Some Conceptual and Ethical Issues. *Milbank Mem Fund Q*, 60, pp.51-81.

Delamater, P., Messina, J., Shortridge, A. and Grady, S. (2012) Measuring Geographic Access to Health Care: Raster and Network-based Methods, *International Journal of Health Geographics*, 11, pp.15.

Delamater, P. (2013) Spatial Accessiblitiy in Suboptimally Configured Health Care Systems: A Modified Two-step Floating Catchment Area (M2SFCA) Metric, *Health & Place*, 24, pp.30-43.

Delamothe, T. (2008) NHS at 60: Founding Principles, *BMJ*, 336(7655): 1216–1218.

DCLG (2015) English Indices of Deprivation 2015. Available from:

https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

[Accessed: 30/07/2016]

Department of Health (2002) Improvement, Expansion and Reform: The Next 3 Years -- Priorities and Planning Framework, 2003-2006. Available from:

http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/Browsable/DH_4098656?IdcService=GET_FILE&dID=10880&Rendition=Web

[Accessed: 30/06/2016]

Department of Health (2002) Shifting the Balance of Power: The Next Steps. Available from: www.dh.gov.uk/en/Publicationsand statistics/Publications/PublicationsPolicyAndGuidance/DH_ 4008424

[Accessed: 01/09/2016]

Department of Health (2003) Tackling Health Inequalities: A Programme for Action. Available from:

http://www.bristol.ac.uk/poverty/downloads/keyofficialdocuments/Tackling%20HE%20program%20for%20action.pdf

[Accessed: 30/06/2016]

Department of Health (2010) Equity and excellence: Liberating the NHS. Available from:

www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAnd Guidance/DH_117353

[Accessed: 01/09/2016]

Department of Health (2013) *SHA and PCT annual reports and accounts 2012 to 2013*. Available from:

https://www.gov.uk/government/collections/sha-and-pct-annual-reports-and-accounts-2012-to-2013

[Accessed: 01/09/2016]

Donabedian, A. (1973) Aspects of Medicalcare Administration: Specifying Requirements for Health Care. Cambridge: Harvard University Press.

Farber, S., Morang, M. and Widener, M. (2014) Temporal Variablity in Transit-based Accessiblity to Supermarkets, *Applied Geopraphy*, 53, pp.149-159.

Fein R. (1972) On Achieving Access and Equity in Health Care, *Milbank Memorial Fund Quarterly*, 50(4), pp.157-190.

Figueroa, J., Morgan, M. Gibson, B. and Beech, R. (2001) What does 'Access to Health Care' Mean? – Access to Health Care, *Journal of Health Services Research & Policy*. Available from:

http://hsr.sagepub.com/content/7/3/186.abstract

[Accessed: 25/08/2016]

Fortney, J., Rost, K. and Warren, J. (2000) Comparing Alternative Methods of Measuring Geographic Access to Health Services, *Health Services & Outcomes Research Methodology*, 1(2), pp.173-184.

Fransen, K., Neutens, T., Maeyer, P. and Deruyter, G. (2015) A Commuter-based Two Step Floating Catchment Area Method for Measuring Spatial Accessiblity of Daycare Centers, *Health & Place*, 32, pp.65-73.

Freeborn, D. and Greenlick, M. (1973) Evaluation of the Performance of Ambulatory Care Systems: Research Requirements and Opportunities, *Medical Care*, 6(2), pp.68-75.

Geertman, S. and van Eck, J. (1995) GIS and Models of Accessibility Potential: An Application in Planning, *International Jounal of Geographical Information Systems*, 9(1), pp.67-80.

Goddard, M. and Smith, P. (1998) Equity of Access to Health Care. Available from:

https://www.york.ac.uk/media/che/documents/papers/occasionalpapers/CHE%20Occasional%20Paper%2032.pdf

[Accessed: 25/08/2016]

Goddard, M. and Smith, P. (2001) Equity of Access to Health Care Services: Theory and Evidence from the UK, *Social Science & Medicine*, 53, pp.1149-1162.

Goodchild, M. (2011) Scale in GIS: An Overview, *Geomorphology*, 130, pp.5-9.

Green, S., Poots, A., Marcano-Belisario, J., Samarasundera, E., Green, J. Honeybourne, E. and Barnes, R. (2012) Mapping Mental Health Service Access: Achieving Equity through Quality Improvement, *Journal of Public Health*, 35(2), pp.286-292.

Gregory, P., Malka, E., Kostis, J., Wilson, A. Arora, J and Rhoads, G. (2000) Impact of Geographic Proximity to Cardiac Revascularization Services on Service Utilization, *Medical Care*, 38, pp.45-57.

Grosios, K, Gahan, P. and Burbidge, J. (2010) Overview of Healthcare in the UK, *EPMA*

Journal, 1, pp.529-534.

Grosios, K., Gahan, P. and Burbidge, J. (2012) Healthcare in the UK - Predictive, Preventive and Personalised Medicine Perspective at the Beginning of the Twenty-First Century in Health Overview: New Perspectives. Springer.

Guagliardo, M. (2004) Spatial Accessibility of Primary Care: Concepts, Methods and Challenges, *International Journal of Health Geographics*, 3(3).

Halden, D., Jones, P. and Wixey, S. (2005) Measuring Accessibility as Experienced by Different Socially Disadvantaged Groups: Accessibility Analysis Literature Review. Available from:

http://home.wmin.ac.uk/transport/download/SAMP_WP3_Accessibility_Modelling.pdf

[Accessed: 01/11/2015]

Hart, J. (1971) The Inverse Care Law, *The Lancet*, 297(7696), pp.405-412.

Haynes, R., Bentham, G., Lovett, A. and Gale, S. (1999) Effects of Distances to Hospital and GP Surgery on Hospital Inpatient Episodes, Controlling for Needs and Provision. *Social Science and Medicine*, 49, pp.425-33.

Haynes, R. and Gale, S. (1999) Mortality, Long–term Illness and Deprivation in Rural and Metropolitan Wards of England and Wales, *Health & Place*, 5, pp.301-12.

Haynes, R. and Gale, S. (2000) Deprivation and Poor Health in Rural Areas: Inequalities Hidden by Averages, *Health & Place*, 6, pp.275-85.

Hewko, J., Smoyer-Tomic, E. and Hodgson, M. (2002) Measuring Neighborhood Spatial Accessibility to Urban Amenities: Does Aggregation Error Matter? *Environment and Planning A,* 34(7), pp.1185-1206.

Heynen, N., Perkins, H. and Roy, P. (2006) The Political Ecology of Uneven Urban Green Space: The Impact of Political Economy on Race and Ethnicity in Producing Environmental Inequality in Milwaukee, *Urban Affairs Review*, 42(1), pp.3-25.

Higgs, G. (2004) A Literature Review of the Use of GIS-Based Measures of Access to Health Care Services, *Health Services & Outcomes Research Methodology*, 5, pp.119-139.

Higgs, G. and White, S. (2000) Alternatives to Census-based Indicators of Social Disadvantage in Rural Communities, *Progress in Planning*, 53, pp.1-81.

Higgs, G., Fry, R. and Langford, M. (2012) Investigating the Implications of Using Alternative GIS-based Techniques to Measure Accessibility to Green Space, *Environment and Planning B: Planning and Design*, 39, pp.326-343.

Hillman, M., Henderson, I. and Whalley, A. (1973) Personal Mobility and Transport Policy. London: George and Berridge & Co. Ltd.

Hopkins, E., Pye, A. and Solomon, M. (1968) The Relation of Patients' Age, Sex and Distance from Surgery to the Demand on the Family Doctor, *Journal of the Royal College of General Practitioners,* 16, pp.368-378.

Hyndman, J. Holman, C. (2001) Accessibility and Spatial Distribution of General Practice Services in An Australian City by Levels of Social Disadvantage, *Social Science & Medicine*, 53, pp.1599-1609.

Joseph, A. and Bantock, P. (1982) Measuring Potential Physical Accessibility to General Practitioners in Rural Areas: A Method and Case Study, *Social Science and Medicine,* 16(1), pp.85-90.

Joseph, A. and Phillips, D. (1984) Accessibility and Utilization: Geographical Perspectives on Health Care Delivery. London: Harper & Row Ltd.

Khan, A. (1992) An Integrated Approach to Measuring Potential access to Health Care Services, *Socio-Economic Planning Sciences*, 26(4), pp.275-287.

Knox, P. (1978) The Intraurban Ecology of Primary Medical Care: Patterns of Accessibility and Their Policy Implications, *Environment and Planning A*, 10, pp.415-435.

Knox, P. (1979) The Accessibility of Primary Care to Urban Patients: A Geographical Analysis, *Journal of the Royal College of General Practitioners*, 29, pp.160-168.

Kovar, M. 1986 Expenditures for the Medical Care of Elderly People Living in the Community in 1980, *The Milbank Quarterly*, 64(1), pp.101-32.

Landry, S. and Chakraborty, J. (2009) Street trees and equity: evaluating the spatial distribution of an urban amenity, *Environment and Planning A*, 41, pp.2651-2670.

Landry, S. and Pu, R. (2010) The Impact of Land Development Regulation on Residential Tree Cover: An Empirical Evaluation Using High-resolution IKONOS Imagery, *Landscape and Urban Planning*, 94, pp.94-104.

Langford, M. and Higgs, G. (2006) Measuring Potential Access to Primary Healthcare Services: The Influence of Alternative Spatial Representations of Population, *The Professional Geographer*, 58(3), pp.294-306.

Langford, M., Higgs, G., Radcliffe, J. and White, S. (2007), Urban Population Distribution Models and Service Accessibility Estimation, *Computers, Environment and Urban Systems*, 32, pp.66-80.

Langford, M., Higgs, G. and Fry, R. (2016) Multi-modal Two-step Floating Catchment Area Analysis of Primary Health Care Accessibility, *Health & Place*, 38, pp.70-81.

La Rosa, D. (2014) Accessibility to Greenspaces: GIS Based Indicators for Sustainable Planning in A Dense Urban Context, *Ecological Indicators*, 42, pp.122-134.

Lee, R. (1978) Designation of Health Manpower Shortage Areas for Use by Public Health Service Programs, *Public Health Reports*, 94(1), pp.48-59.

Levesque, J., Harris, M. and Russell, G. (2013) Patient-centred Access to Health Care: Conceptualising Access at the Interface of Health Systems and Populations, *International Journal for Equity in Health*, 12(18).

Li, T., Pullar, D., Corcoran, J and Stimson, R. (2007) A Comparison of Spatial Disaggregation Techniques as Applied to Population Estimation for South East Queensland (SEQ), Australia, *Applied GIS*, 3(9), pp.1-16.

Lindsey, G., Maraj, M. and Kuan, S. (2001) Access, Equity, and Urban Greenways: An Exploratory Investigation, *The Professional Geographer*, 53(3), pp.332-346.

Litman, T. (2015) Evaluating Accessibility for Transportation Planning: Measuring People's Ability to Reach Desired Goods and Activities 24 August 2015. Available at: http://www.vtpi.org/access.pdf

[Accessed: 01/11/2015]

Liu, S. and Zhu, X. (2004) Accessibility Analyst: in integrated GIS tool for accessibility analysis in urban transportation planning, *Environment and Planning B: Planning and Design*, 31, pp.105-124.

Love, D. and Lindquist, P. (1995) The Geographical Accessibility of Hospitals to the Aged: A Geographic Information Systems Analysis within Illinois, *Health Services Research*, 29(6), pp.629-651.

Lovett, A. et al. (2002) Car Travel Time and Accessibility by Bus to General Practitioner Services: A Study Using Patient Registers and GIS, *Social Science & Medicine*, 55, pp.97-111.

Lucy, W. (1981) Equity and Planning for Local Services, *Journal of the American Planning Association*, 47(4), pp.447-457.

Luo, W. and Wang, F. (2003) Measures of Spatial Accessibility to Health Care in a GIS Environment: Synthesis and A Case Study in the Chicago Region. *Environment and Planning B*, 30, pp.865-84.

Luo, W. (2004) Using A GIS-based Floating Catchment Method to Assess Areas with Shortage of Physicians, *Health & Place*, 10, pp.1-11.

Luo, W. and Qi, Y. (2009) An Enhanced Two-step Floating Catchment Area (E2SFCA) Method for Measuring Spatial Accessibility to Primary Care Physicians. *Health & Place 15*, pp.1100-1107.

Lynch, K. (1984) Good City Form. The MIT Press.

Maantay, J., Maroko, A. and Herrmann, C. (2007) Mapping Population Distribution in the Urban Environment: The Cadastral-based Expert Dasymetric System (CEDS), *Cartography and Geographic Information Science*, 34(2), pp.77-102.

Makuc, D. Haglund, B. Ingram, D., Kleinman, J. and Feldman, J. (1991) The Use of Health Service Areas for Measuring Provider Availability, *Public Health Resources*, pp.347-456.

Martin, D., Wrigley, H., Barnett, S. and Roderick, P. (2002) Increasing the Sophistication of Access Measurement in A Rural Healthcare Study, *Health & Place*, 8, pp.3-13.

Miller, D. (2003) Political Philosophy: A Very Short Introduction. Oxford University Press.

Moore, D. and Carpenter, T. (1999) Spatial Analytical Methods and Geographic Information Systems: Use in Health Research and Epidemiology, *Epidemiologic Reviews*, 21(2), pp.143-161.

Moseley, M. (1979) Accessibility: The Rural Challenge. London: Methuen.

Nemet, G. and Bailey, A. (2000) Distance and Health Care Utilization among the Rural Elderly. *Social Science and Medicine*, 50, pp.1197-1208.

NHS (2013) Guide to the Healthcare System in England Including the Statement of NHS Accountability (for England). Available from:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/194002/9421-2900878-TSO-NHS_Guide_to_Healthcare_WEB.PDF

[Accessed: 01/09/2016]

Nicholls, S. (2001) Measuring the accessibility and equity of public parks: a case study using GIS, *Managing Leisure*, 6, pp.201-219.

Nicol, J. (1991) Geographic Information Systems within the National Health Service: the Scope for Implementation, *Planning Outlook*, 34, pp.37-42.

Nutley, S. (1985) Planning Options for the Improvement of Rural Accessibility: Use of the Time-Space Approach, *Regional Studies*, 19 (1), pp.37-50.

Oliver, A. and Mossialos, E. (2004) Equity of Access to Health Care: Outlining the Foundations for Action, *J Epidemiol Community Health*, 58, pp.655-658.

Oliver, A. (2005) The English National Health Service: 1979-2005, *Health Economics*, 14, pp.75-S99.

Omer, I. (2006) Evaluating accessibility using house-level data: A spatial equity perspective, *Computers, Environment and Urban Systems*, 30, pp.254-274.

ONS (2011) 2011 Census Glossary of Terms. Available from:

http://www.ons.gov.uk/ons/guide-method/census/2011/census-data/2011-census-user-guide/glossary/index.html

[Accessed: 15/03/2015]

ONS (2013) Population Weighted Centroids Guidance. Available from:
http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/guide-method/geography/products/census/spatial/centroids/index.html
[Accessed: 09/03/2016]

Penchansky, R. and Thomas, J. (1981) The concept of access: definition and relationship to consumer satisfaction, *Med Care*, 198, 19(2), pp.127–140.

Pham, T. (2012) Spatial distribution of vegetation in Montreal: An uneven distribution or environmental inequity?, *Landscape and Urban Planning*,107, pp.214–224.

Phillips, D. (1979) Spatial Variations in Attendance at General Practitioner Services,

Social Science & Medicine. Part D: Medical Geography, 13(3), pp.169-181.

Powell, T. (2017) The Structure of the NHS in England. Briefing Paper Number CBP 07206. Available from: researchbriefings.files.parliament.uk/documents/CBP-7206/CBP-7206.pdf [Accessed: 09/09/2017]

Radke, J. and Mu, L. (2000) Spatial Decomposition, Modelling and Mapping Service Regions to Predict Access to Social Programs, *Geographic Information Sciences*, 6, pp.105-12.

Parker, E. and Campbell, J. (1998) Measuring Access to Primary Medical Care: Some Examples of the Use of Geographical Information Systems, *Health & Place*, 4(2), pp.183-193.

Public Health England (2013) Health Profile Newcastle upon Tyne 2013. Available from: http://www.newcastlegatesheadccg.nhs.uk/wp-content/uploads/2015/02/HealthProfile2013NewcastleuponTyne00CJ1.pdf

[Accessed: 25/01/2017]

Rawls, J. (1999) A Theory of Justice (Rev. ed.). US: Harvard University Press.

Rice, D. and Feldman, J. (1983) Living Longer in the United States: Demographic Changes and Health Needs of the Elderly, *The Milbank Memorial Fund Quarterly: Health and Society*, 61(3), pp.362-96.

Rogers, A., Hassell, K. and Nicolaas, G. (1999) Demanding Patients? Analyzing the Use of Primary Care. Buckingham: Open University Press.

Sampson, E. (1975). On Justice as Equality. *Journal of Social Issues*, 31(3).

Sander, H. Ghosh, D. and Riper, D. (2010) How do You Measure Distance in Spatial Models? An Example Using Open-space Valuation, *Environment and Planning B: Planning and Design*, 37, pp.874-894.

Scaife, B., Gill, P., Heywood, P. and Neal, R. (2000) Socio-economic Characteristics of Adult Frequent Attenders in General Practice: Secondary Analysis of Data, *Family Practice*, 17(4), pp.298-304.

Sidgwick, H. (1981) The Methods of Ethics. Hackett Publishing.

Simpson, P. and Varma, A. (2006) Distributive Justice Revisited: A Reconceptualization and An Empirical Test, *Journal of Labor Research*, 27(2), pp.237-262.

Smoyer-Tomic, K., Hewko, J. and Hodgson, M (2004) Spatial Accessibility and Equity of Playgrounds in Edmonton, *Canadian Geographer*, 48(3), pp.1-16.

Stan, C., Geertman, M. and Van Eck, J. (1995) GIS and Models of Accessibility Potential: An Application in Planning, *International Journal of Geographical Information Systems*, 9(1), pp.67-80.

Sullivan, G. and Feinn, R. (2012) Using Effect Size -- or Why the P Value Is Not Enough, *Journal of Graduate Medical Education*, pp.279-282.

Taleai, M., Sliuzas, R. and Flacke, J. (2014) An integrated framework to evaluate the equity of urban public facilities using spatial multi-criteria analysis, *Cities*, 40, pp.56-69.

Talen, E. (1998) Visualizing Fairness: Equity Maps for Planners, *Journal of the American Planning Association*, 64:1, pp.22-38.

Talen, E. (2001) School, Community, and Spatial Equity: An Empirical Investigation of Access to Elementary Schools in West Virginia, *Annals of the Association of American Geographers*, 91(3), pp.465-486.

Talen, E. (2003) Neighborhoods as Service Providers: A Methodology for Evaluating Pedestrian Access, *Environment and Planning B*, 30(2), pp.181.

Talen, E. and Anselin, L. (1998) Assessing Spatial Equity: An Evaluation of Measures of Accessibility to Public Playgrounds, *Environment and Planning A*, 30, pp.595-613.

The Scottish Government (2012) Scottish Index of Multiple Deprivation. Available from:

http://simd.scotland.gov.uk/publication-2012/

[Accessed: 30/07/2016]

Todd, A., Copeland, A., Husband, A., Kasim, A. and Bambra, C. (2014) The Positive Pharmacy Care Law: An Area-level Analysis of the Relationship between Community Pharmacy Distribution, Urbanity and Social Deprivation in England, *BMJ Open*, 5, pp.1-8.

Todd, A., Copeland, A., Husband, A., Kasim, A. and Bambra, C. (2015) Access All Areas? An Area-level Analysis of Accessibility to General Practice and Community Pharmacy Services in England by Urbanity and Social Deprivation, *BMJ Open*, 4, pp.1-7.

Tooke, T., Klinkenberg, B. and Coops, N. (2010) A Geographical Approach to Identifying Vegetation-related Environmental Equity in Canadian Cities, *Environment and Planning B: Planning and Design*, 37, pp.1040-1056.

Townsend, P. (1987) Deprivation, *Journal of Social Policy*, 16, pp.125-146.

Troy, A. (2007) Predicting Opportunities for Greening and Patterns of Vegetation on Private Urban Lands, *Environ Manage*, 40, pp.394-412.

Turner, M., Dale, V. and Gardner, R. (1989) Predicting across Scales: Theory Development and Testing, *Landscape Ecology*, 3, pp.245-252.

Wagstaff, G. (1994) Equity, Equality, and Need: Three Principles of Justice or One? An Analysis of "Equity as Desert". *Current Psychology*, 13(2), pp.138-152.

Wan, N. Zhan, F., Zou, B. and Chow, E. (2012a) A Relative Spatial Access Assessment Approach for Analyzing Potential access to Colorectal Cancer Services in Texas, *Applied Geography*, 32, pp.291-299.

Wan, N., Zou, B. and Sternberg, T. (2012b) A Three-step Floating Catchment Area Method for Analyzing Spatial Access to Health Services. *International Journal of Geographical Information Science*, 26, pp.1073-1089.

Wang, F. (2012) Measurement, Optimization, and Impact of Health Care Accessibility: A Methodological Review, *Annals of the Association of American Geographers,* 102(5), pp.1104-1112.

Wang, F. and Luo, W. (2005) Assessing Spatial and Nonspatial Factors for Healthcare Access: Towards An Integrated Approach to Defining Health Professional Shortage Areas, *Health & Place*, 11, pp.131-46.

Webster C. (2002) The National Health Service: A Political History. Oxford University Press: Oxford.

Whitehead, M. (1992) The Concepts and Principles of Equity and Health, *Int J Health Serv*, 22, pp.429-445.

Wicks, B. and Crompton, J. (1987) An Analysis of the Relationship between Equity Choice Preferences, Service Type and Decision Making Groups in A U.S. City, *Journal of Leisure Research*, 19(3), pp.189-204.

Wing, P. and Reynolds, C. (1988) The Availability of Physician Services: A Geographic Analysis, *HSR: Health Services Research*, 23(5), pp.649-667.

Wood, D., Clark, D. and Gatrell, A. (2004) Equity of Access to Adult Hospice Inpatient Care within North-West England, *Palliative Medicine*, 18, pp.543-549.

Wu, J. and Li, H. (2006) Concepts of Scale and Scaling. In J. Wu, B. Jones, H. Li, and O. Loucks, eds. *Scaling and Uncertainty Analysis in Ecology: Methods and Applications*. Dordrecht, the Netherlands: Springer, pp.3-15.

Zhang, X., Lu, H. and Holt, J. (2011) Modeling spatial accessibility to parks: a national study, *International Journal of Health Geographics*, 10, pp.31.

Appendices

Appendix A: Application of the HSW Technique to Estimate Population of Output Areas Located inside the Merged Service Areas of All GP Practices in Newcastle

OAs in Newcastle	Population in OA	OAs with Population inside the Service Area	Weight of OA inside the Service Area	Population inside the Service Area
E00042042	268	**E00042042**	0.37	**100**
E00042043	340	**E00042043**	0.45	**153**
E00042044	264	**E00042044**	0.30	**79**
E00042045	234	**E00042045**	0.75	**176**
E00042046	461	**E00042046**	0.85	**392**
E00042047	346	**E00042047**	1.00	**346**
E00042048	355	**E00042048**	0.74	**264**
E00042049	336		0.00	**0**
E00042050	388		0.00	**0**
E00042051	312	**E00042051**	0.96	**300**
E00042052	329	**E00042052**	0.67	**219**
E00042053	309	**E00042053**	0.24	**73**
E00042054	291	**E00042054**	0.99	**287**
E00042055	314		0.00	**0**
E00042056	236	**E00042056**	0.94	**222**
E00042057	393	**E00042057**	0.67	**262**
E00042058	124	**E00042058**	1.00	**124**
E00042059	324	**E00042059**	1.00	**324**
E00042061	342	**E00042061**	1.00	**342**
E00042062	501	**E00042062**	1.00	**501**
E00042064	351	**E00042064**	1.00	**351**
E00042065	298	**E00042065**	1.00	**298**
E00042066	132	**E00042066**	1.00	**132**
E00042067	353		0.00	**0**
E00042068	320	**E00042068**	1.00	**320**
E00042069	334	**E00042069**	0.30	**99**
E00042070	287	**E00042070**	0.80	**229**
E00042071	275	**E00042071**	0.42	**115**
E00042072	278	**E00042072**	1.00	**278**
E00042073	328	**E00042073**	0.36	**119**
E00042074	250	**E00042074**	0.02	**4**
E00042075	361		0.00	**0**
E00042076	371		0.00	**0**
E00042077	245	**E00042077**	0.06	**15**
E00042078	256	**E00042078**	0.69	**176**
E00042079	244	**E00042079**	0.13	**31**
E00042080	248	**E00042080**	0.99	**246**
E00042081	433		0.00	**0**
E00042082	296	**E00042082**	0.89	**263**
E00042083	313	**E00042083**	0.04	**13**

E00042084	236	**E00042084**	0.69	**164**
E00042085	248		0.00	**0**
E00042086	335	**E00042086**	0.58	**194**
E00042087	304	**E00042087**	0.63	**190**
E00042088	360	**E00042088**	1.00	**360**
E00042089	194	**E00042089**	0.80	**156**
E00042090	267	**E00042090**	0.56	**149**
E00042091	362	**E00042091**	0.90	**325**
E00042092	295		0.00	**0**
E00042093	253		0.00	**0**
E00042094	202		0.00	**0**
E00042095	281		0.00	**0**
E00042096	218		0.00	**0**
E00042097	396		0.00	**0**
E00042099	397		0.00	**0**
E00042100	327	**E00042100**	1.00	**327**
E00042101	243	**E00042101**	1.00	**243**
E00042102	399	**E00042102**	0.03	**13**
E00042103	323	**E00042103**	1.00	**323**
E00042104	488	**E00042104**	1.00	**488**
E00042106	363	**E00042106**	1.00	**363**
E00042107	263	**E00042107**	0.26	**69**
E00042108	310	**E00042108**	0.13	**39**
E00042109	298		0.00	**0**
E00042110	250		0.00	**0**
E00042111	227	**E00042111**	1.00	**227**
E00042112	280	**E00042112**	1.00	**280**
E00042113	279		0.00	**0**
E00042114	256	**E00042114**	0.10	**25**
E00042115	299	**E00042115**	0.62	**186**
E00042116	255		0.00	**0**
E00042117	227		0.00	**0**
E00042118	460		0.00	**0**
E00042120	342	**E00042120**	0.11	**39**
E00042121	284		0.00	**0**
E00042122	257	**E00042122**	0.13	**33**
E00042123	210		0.00	**0**
E00042124	206		0.00	**0**
E00042125	208	**E00042125**	1.00	**208**
E00042126	328	**E00042126**	0.86	**282**
E00042127	342	**E00042127**	1.00	**342**
E00042128	168	**E00042128**	1.00	**168**
E00042129	466	**E00042129**	1.00	**466**
E00042130	280	**E00042130**	0.14	**39**
E00042131	216	**E00042131**	0.25	**53**

E00042132	225	**E00042132**	1.00	**225**
E00042133	279	**E00042133**	0.36	**101**
E00042134	299	**E00042134**	1.00	**299**
E00042135	267		0.00	**0**
E00042136	285	**E00042136**	0.97	**276**
E00042137	245		0.00	**0**
E00042138	301		0.00	**0**
E00042139	263		0.00	**0**
E00042140	294	**E00042140**	0.72	**213**
E00042141	352	**E00042141**	0.71	**250**
E00042142	324		0.00	**0**
E00042143	299		0.00	**0**
E00042144	279		0.00	**0**
E00042145	274	**E00042145**	0.02	**5**
E00042146	294		0.00	**0**
E00042147	526		0.00	**0**
E00042148	304		0.00	**0**
E00042149	320	**E00042149**	0.62	**197**
E00042150	293	**E00042150**	0.08	**25**
E00042151	278	**E00042151**	0.08	**21**
E00042152	321		0.00	**0**
E00042153	256		0.00	**0**
E00042154	271		0.00	**0**
E00042155	286		0.00	**0**
E00042156	216		0.00	**0**
E00042157	274		0.00	**0**
E00042158	305		0.00	**0**
E00042159	313		0.00	**0**
E00042160	297		0.00	**0**
E00042161	294		0.00	**0**
E00042162	153		0.00	**0**
E00042164	259		0.00	**0**
E00042165	278		0.00	**0**
E00042166	229		0.00	**0**
E00042168	265		0.00	**0**
E00042169	291	**E00042169**	1.00	**291**
E00042170	314	**E00042170**	1.00	**314**
E00042171	312		0.00	**0**
E00042172	228		0.00	**0**
E00042173	314	**E00042173**	1.00	**314**
E00042174	317	**E00042174**	1.00	**317**
E00042175	323	**E00042175**	0.18	**58**
E00042176	340	**E00042176**	1.00	**340**
E00042177	253	**E00042177**	0.71	**180**
E00042178	337	**E00042178**	0.73	**248**

E00042179	260	**E00042179**	0.30	**78**
E00042180	539		0.00	**0**
E00042182	385		0.00	**0**
E00042183	317		0.00	**0**
E00042184	429	**E00042184**	0.03	**11**
E00042185	339		0.00	**0**
E00042186	189		0.00	**0**
E00042187	586		0.00	**0**
E00042188	340	**E00042188**	0.43	**147**
E00042189	269		0.00	**0**
E00042190	355	**E00042190**	1.00	**355**
E00042191	256		0.00	**0**
E00042192	226		0.00	**0**
E00042193	317		0.00	**0**
E00042194	336	**E00042194**	0.08	**27**
E00042195	351	**E00042195**	0.10	**35**
E00042196	311		0.00	**0**
E00042197	266	**E00042197**	0.85	**226**
E00042198	257		0.00	**0**
E00042199	288	**E00042199**	0.87	**251**
E00042200	284	**E00042200**	1.00	**284**
E00042201	299		0.00	**0**
E00042202	331		0.00	**0**
E00042203	237	**E00042203**	0.74	**175**
E00042205	309	**E00042205**	0.02	**5**
E00042206	269	**E00042206**	1.00	**269**
E00042207	330		0.00	**0**
E00042208	234		0.00	**0**
E00042209	276		0.00	**0**
E00042210	292		0.00	**0**
E00042211	271		0.00	**0**
E00042212	307		0.00	**0**
E00042213	452		0.00	**0**
E00042214	282	**E00042214**	0.47	**133**
E00042215	304	**E00042215**	0.03	**8**
E00042216	267	**E00042216**	0.36	**97**
E00042217	326		0.00	**0**
E00042218	301		0.00	**0**
E00042219	328		0.00	**0**
E00042220	353		0.00	**0**
E00042221	200		0.00	**0**
E00042222	303		0.00	**0**
E00042223	297		0.00	**0**
E00042224	292		0.00	**0**
E00042225	291		0.00	**0**

E00042226	157		0.00	**0**
E00042227	255		0.00	**0**
E00042228	424	**E00042228**	0.39	**167**
E00042229	262	**E00042229**	1.00	**262**
E00042230	324		0.00	**0**
E00042232	325		0.00	**0**
E00042233	304	**E00042233**	1.00	**304**
E00042234	340	**E00042234**	0.14	**47**
E00042235	290	**E00042235**	0.15	**44**
E00042236	227	**E00042236**	0.60	**135**
E00042237	119	**E00042237**	0.69	**82**
E00042238	366	**E00042238**	0.36	**133**
E00042240	287	**E00042240**	1.00	**287**
E00042241	252	**E00042241**	0.42	**105**
E00042242	277	**E00042242**	0.72	**199**
E00042243	257	**E00042243**	0.81	**207**
E00042244	329	**E00042244**	0.30	**99**
E00042245	451	**E00042245**	0.14	**64**
E00042246	235	**E00042246**	0.77	**181**
E00042247	162	**E00042247**	1.00	**162**
E00042248	272	**E00042248**	0.16	**43**
E00042249	251	**E00042249**	1.00	**251**
E00042250	258	**E00042250**	1.00	**258**
E00042251	365	**E00042251**	0.06	**21**
E00042252	221	**E00042252**	0.03	**7**
E00042253	260	**E00042253**	1.00	**260**
E00042254	282	**E00042254**	1.00	**282**
E00042255	326	**E00042255**	0.68	**221**
E00042256	323	**E00042256**	0.91	**295**
E00042257	267	**E00042257**	0.79	**212**
E00042258	289	**E00042258**	1.00	**289**
E00042259	294	**E00042259**	0.18	**52**
E00042260	386	**E00042260**	0.01	**3**
E00042261	280	**E00042261**	1.00	**280**
E00042262	534	**E00042262**	1.00	**534**
E00042263	340	**E00042263**	1.00	**340**
E00042264	288	**E00042264**	1.00	**288**
E00042265	366	**E00042265**	1.00	**366**
E00042266	512	**E00042266**	1.00	**512**
E00042267	401	**E00042267**	1.00	**401**
E00042268	243	**E00042268**	0.62	**151**
E00042269	405	**E00042269**	1.00	**405**
E00042270	400	**E00042270**	1.00	**400**
E00042271	445	**E00042271**	1.00	**445**
E00042272	609	**E00042272**	1.00	**609**

E00042273	463	**E00042273**	1.00	**463**
E00042274	291	**E00042274**	1.00	**291**
E00042275	468	**E00042275**	1.00	**468**
E00042276	372	**E00042276**	1.00	**372**
E00042277	413	**E00042277**	1.00	**413**
E00042278	256	**E00042278**	1.00	**256**
E00042279	394	**E00042279**	1.00	**394**
E00042280	494	**E00042280**	1.00	**494**
E00042281	353	**E00042281**	1.00	**353**
E00042282	310	**E00042282**	1.00	**310**
E00042283	182	**E00042283**	1.00	**182**
E00042284	489	**E00042284**	1.00	**489**
E00042285	404	**E00042285**	1.00	**404**
E00042286	394	**E00042286**	1.00	**394**
E00042287	298	**E00042287**	1.00	**298**
E00042288	304		0.00	**0**
E00042289	263	**E00042289**	0.51	**134**
E00042290	265	**E00042290**	0.92	**243**
E00042291	260	**E00042291**	0.46	**119**
E00042292	226		0.00	**0**
E00042293	292	**E00042293**	1.00	**292**
E00042294	278	**E00042294**	0.99	**276**
E00042295	369	**E00042295**	1.00	**369**
E00042296	256	**E00042296**	1.00	**256**
E00042297	289	**E00042297**	1.00	**289**
E00042298	235	**E00042298**	0.11	**25**
E00042299	340	**E00042299**	1.00	**340**
E00042300	277	**E00042300**	1.00	**277**
E00042301	334	**E00042301**	1.00	**334**
E00042302	312	**E00042302**	0.65	**203**
E00042303	225	**E00042303**	1.00	**225**
E00042304	297	**E00042304**	1.00	**297**
E00042305	327	**E00042305**	0.41	**134**
E00042306	246	**E00042306**	1.00	**246**
E00042307	265	**E00042307**	1.00	**265**
E00042308	336	**E00042308**	1.00	**336**
E00042309	246		0.00	**0**
E00042310	171	**E00042310**	0.04	**7**
E00042311	216	**E00042311**	0.24	**51**
E00042312	262	**E00042312**	0.53	**138**
E00042313	301	**E00042313**	0.87	**263**
E00042314	267	**E00042314**	0.16	**44**
E00042315	268	**E00042315**	0.65	**174**
E00042316	343	**E00042316**	1.00	**343**
E00042317	377	**E00042317**	1.00	**377**

E00042318	405	**E00042318**	0.42	**171**
E00042319	301	**E00042319**	0.97	**291**
E00042320	263	**E00042320**	0.35	**93**
E00042321	158	**E00042321**	1.00	**158**
E00042322	256	**E00042322**	1.00	**256**
E00042323	316	**E00042323**	1.00	**316**
E00042324	333	**E00042324**	1.00	**333**
E00042325	257	**E00042325**	1.00	**257**
E00042326	358		0.00	**0**
E00042327	270		0.00	**0**
E00042328	369	**E00042328**	0.58	**212**
E00042329	196	**E00042329**	0.14	**27**
E00042330	207	**E00042330**	0.76	**157**
E00042331	201		0.00	**0**
E00042332	533		0.00	**0**
E00042333	289	**E00042333**	0.07	**21**
E00042334	281	**E00042334**	0.53	**148**
E00042335	319	**E00042335**	1.00	**319**
E00042336	255	**E00042336**	1.00	**255**
E00042337	310	**E00042337**	0.78	**242**
E00042338	394	**E00042338**	1.00	**394**
E00042339	318	**E00042339**	1.00	**318**
E00042340	276	**E00042340**	1.00	**276**
E00042341	268	**E00042341**	0.77	**205**
E00042342	284	**E00042342**	0.06	**17**
E00042343	297	**E00042343**	0.05	**13**
E00042344	202	**E00042344**	0.92	**187**
E00042345	294	**E00042345**	0.89	**260**
E00042347	312	**E00042347**	0.86	**269**
E00042348	309	**E00042348**	0.81	**252**
E00042349	389	**E00042349**	0.68	**263**
E00042350	408	**E00042350**	0.50	**205**
E00042351	281	**E00042351**	0.48	**135**
E00042352	293	**E00042352**	0.29	**85**
E00042353	268		0.00	**0**
E00042354	325	**E00042354**	1.00	**325**
E00042355	355	**E00042355**	1.00	**355**
E00042356	414	**E00042356**	1.00	**414**
E00042357	471	**E00042357**	1.00	**471**
E00042358	132		0.00	**0**
E00042359	165		0.00	**0**
E00042360	315	**E00042360**	0.04	**11**
E00042361	249	**E00042361**	0.25	**63**
E00042362	225		0.00	**0**
E00042363	294	**E00042363**	1.00	**294**

E00042364	266	**E00042364**	0.18	**48**
E00042365	250		0.00	**0**
E00042366	253	**E00042366**	0.19	**47**
E00042367	222	**E00042367**	0.13	**28**
E00042368	328		0.00	**0**
E00042369	220	**E00042369**	0.77	**170**
E00042370	267	**E00042370**	1.00	**267**
E00042371	306	**E00042371**	1.00	**306**
E00042372	259	**E00042372**	0.97	**251**
E00042373	360	**E00042373**	1.00	**360**
E00042374	310	**E00042374**	1.00	**310**
E00042375	277	**E00042375**	1.00	**277**
E00042376	240		0.00	**0**
E00042377	270		0.00	**0**
E00042378	353	**E00042378**	1.00	**353**
E00042379	352	**E00042379**	1.00	**352**
E00042380	417		0.00	**0**
E00042381	279	**E00042381**	1.00	**279**
E00042382	247	**E00042382**	1.00	**247**
E00042383	489	**E00042383**	0.33	**163**
E00042384	392		0.00	**0**
E00042385	349	**E00042385**	0.11	**38**
E00042386	313	**E00042386**	0.83	**260**
E00042387	232	**E00042387**	0.80	**186**
E00042388	449	**E00042388**	1.00	**449**
E00042389	274	**E00042389**	1.00	**274**
E00042390	164	**E00042390**	1.00	**164**
E00042391	279	**E00042391**	1.00	**279**
E00042392	196	**E00042392**	0.97	**189**
E00042393	294	**E00042393**	0.67	**196**
E00042394	330	**E00042394**	0.99	**327**
E00042395	200	**E00042395**	1.00	**200**
E00042396	203	**E00042396**	1.00	**203**
E00042397	440	**E00042397**	1.00	**440**
E00042398	253		0.00	**0**
E00042399	313	**E00042399**	0.03	**9**
E00042400	353	**E00042400**	0.45	**159**
E00042401	305		0.00	**0**
E00042402	229	**E00042402**	0.01	**2**
E00042403	400	**E00042403**	0.16	**64**
E00042404	352	**E00042404**	1.00	**352**
E00042405	268	**E00042405**	1.00	**268**
E00042406	578	**E00042406**	0.40	**234**
E00042407	298	**E00042407**	1.00	**298**
E00042408	373	**E00042408**	0.93	**348**

E00042409	272	**E00042409**	1.00	**272**
E00042410	306	**E00042410**	0.79	**241**
E00042411	250	**E00042411**	1.00	**250**
E00042412	356	**E00042412**	0.44	**158**
E00042413	363	**E00042413**	0.41	**147**
E00042414	232	**E00042414**	0.69	**160**
E00042415	328	**E00042415**	0.52	**172**
E00042416	233	**E00042416**	0.85	**198**
E00042417	247	**E00042417**	0.63	**155**
E00042418	303	**E00042418**	1.00	**303**
E00042419	405	**E00042419**	1.00	**405**
E00042420	268	**E00042420**	1.00	**268**
E00042421	218	**E00042421**	1.00	**218**
E00042422	356	**E00042422**	0.88	**312**
E00042423	324	**E00042423**	0.23	**74**
E00042424	310	**E00042424**	1.00	**310**
E00042425	328	**E00042425**	1.00	**328**
E00042426	326	**E00042426**	1.00	**326**
E00042427	388	**E00042427**	1.00	**388**
E00042428	344	**E00042428**	1.00	**344**
E00042429	323	**E00042429**	0.96	**310**
E00042430	244	**E00042430**	0.63	**154**
E00042431	249	**E00042431**	0.98	**244**
E00042432	362	**E00042432**	0.37	**133**
E00042433	237	**E00042433**	0.13	**30**
E00042434	259	**E00042434**	1.00	**259**
E00042435	354	**E00042435**	1.00	**354**
E00042436	232	**E00042436**	1.00	**232**
E00042437	317	**E00042437**	1.00	**317**
E00042438	401	**E00042438**	1.00	**401**
E00042439	598	**E00042439**	1.00	**598**
E00042440	355	**E00042440**	0.74	**263**
E00042441	429	**E00042441**	0.70	**301**
E00042442	524	**E00042442**	1.00	**524**
E00042443	424	**E00042443**	0.91	**387**
E00042444	432	**E00042444**	1.00	**432**
E00042445	220	**E00042445**	0.49	**108**
E00042446	352	**E00042446**	1.00	**352**
E00042447	385	**E00042447**	1.00	**385**
E00042448	542	**E00042448**	1.00	**542**
E00042449	321	**E00042449**	1.00	**321**
E00042450	609	**E00042450**	1.00	**609**
E00042451	379	**E00042451**	1.00	**379**
E00042452	513	**E00042452**	0.43	**218**
E00042453	286	**E00042453**	1.00	**286**

E00042454	340	**E00042454**	0.32	**110**
E00042455	430	**E00042455**	1.00	**430**
E00042456	295	**E00042456**	0.44	**130**
E00042457	616	**E00042457**	1.00	**616**
E00042458	435	**E00042458**	1.00	**435**
E00042459	475	**E00042459**	0.93	**444**
E00042460	414	**E00042460**	0.82	**340**
E00042461	384	**E00042461**	1.00	**384**
E00042462	448	**E00042462**	1.00	**448**
E00042463	390	**E00042463**	1.00	**390**
E00042464	317	**E00042464**	0.84	**266**
E00042465	436	**E00042465**	0.94	**411**
E00042466	301	**E00042466**	1.00	**301**
E00042467	345	**E00042467**	0.36	**124**
E00042468	448	**E00042468**	0.92	**411**
E00042469	226	**E00042469**	1.00	**226**
E00042470	371	**E00042470**	0.86	**318**
E00042471	326	**E00042471**	1.00	**326**
E00042472	189	**E00042472**	0.36	**68**
E00042473	349	**E00042473**	1.00	**349**
E00042474	237	**E00042474**	0.18	**42**
E00042475	338	**E00042475**	1.00	**338**
E00042476	512	**E00042476**	1.00	**512**
E00042477	460	**E00042477**	1.00	**460**
E00042478	367	**E00042478**	1.00	**367**
E00042479	311	**E00042479**	1.00	**311**
E00042480	321	**E00042480**	1.00	**321**
E00042481	363	**E00042481**	0.21	**76**
E00042482	300		0.00	**0**
E00042483	310	**E00042483**	0.49	**151**
E00042484	271	**E00042484**	0.96	**259**
E00042485	302	**E00042485**	1.00	**302**
E00042486	222	**E00042486**	0.02	**4**
E00042487	351	**E00042487**	0.06	**20**
E00042488	254	**E00042488**	0.06	**15**
E00042489	295	**E00042489**	0.79	**233**
E00042490	326		0.00	**0**
E00042491	509		0.00	**0**
E00042492	328		0.00	**0**
E00042493	249	**E00042493**	0.25	**63**
E00042494	282		0.00	**0**
E00042495	193		0.00	**0**
E00042496	335		0.00	**0**
E00042498	299		0.00	**0**
E00042499	333		0.00	**0**

E00042500	401		0.00	**0**
E00042501	218		0.00	**0**
E00042502	388		0.00	**0**
E00042503	367	**E00042503**	0.96	**353**
E00042504	228		0.00	**0**
E00042505	260	**E00042505**	1.00	**260**
E00042506	167		0.00	**0**
E00042507	467	**E00042507**	0.94	**439**
E00042508	195	**E00042508**	1.00	**195**
E00042509	362	**E00042509**	1.00	**362**
E00042510	294	**E00042510**	1.00	**294**
E00042511	294	**E00042511**	0.53	**156**
E00042512	310	**E00042512**	1.00	**310**
E00042513	301	**E00042513**	0.06	**19**
E00042514	311		0.00	**0**
E00042515	258		0.00	**0**
E00042516	363		0.00	**0**
E00042517	240		0.00	**0**
E00042518	250		0.00	**0**
E00042519	318		0.00	**0**
E00042520	265		0.00	**0**
E00042521	319		0.00	**0**
E00042522	325		0.00	**0**
E00042523	331		0.00	**0**
E00042524	288		0.00	**0**
E00042525	369		0.00	**0**
E00042526	324		0.00	**0**
E00042527	234		0.00	**0**
E00042528	317		0.00	**0**
E00042529	237		0.00	**0**
E00042530	289		0.00	**0**
E00042531	260		0.00	**0**
E00042532	293		0.00	**0**
E00042533	269		0.00	**0**
E00042534	247		0.00	**0**
E00042535	266		0.00	**0**
E00042536	287		0.00	**0**
E00042537	307		0.00	**0**
E00042538	287		0.00	**0**
E00042539	256		0.00	**0**
E00042540	262	**E00042540**	0.13	**33**
E00042541	278		0.00	**0**
E00042542	273		0.00	**0**
E00042543	266		0.00	**0**
E00042544	285		0.00	**0**

E00042545	288		0.00	**0**
E00042546	272		0.00	**0**
E00042547	394		0.00	**0**
E00042548	270		0.00	**0**
E00042549	386	**E00042549**	0.63	**242**
E00042550	318	**E00042550**	1.00	**318**
E00042551	296	**E00042551**	1.00	**296**
E00042552	170	**E00042552**	0.90	**153**
E00042553	342	**E00042553**	1.00	**342**
E00042554	286	**E00042554**	0.71	**202**
E00042555	380	**E00042555**	1.00	**380**
E00042556	238		0.00	**0**
E00042557	306	**E00042557**	1.00	**306**
E00042558	200	**E00042558**	1.00	**200**
E00042559	354	**E00042559**	0.15	**53**
E00042560	325		0.00	**0**
E00042561	254		0.00	**0**
E00042562	290		0.00	**0**
E00042563	281		0.00	**0**
E00042564	307		0.00	**0**
E00042565	199		0.00	**0**
E00042566	327		0.00	**0**
E00042567	282		0.00	**0**
E00042568	246		0.00	**0**
E00042569	215		0.00	**0**
E00042570	349	**E00042570**	0.19	**66**
E00042571	210	**E00042571**	0.07	**14**
E00042572	304	**E00042572**	0.87	**265**
E00042573	203	**E00042573**	1.00	**203**
E00042574	328	**E00042574**	1.00	**328**
E00042575	308	**E00042575**	1.00	**308**
E00042576	376	**E00042576**	0.25	**94**
E00042577	274		0.00	**0**
E00042578	313	**E00042578**	0.27	**85**
E00042579	196	**E00042579**	1.00	**196**
E00042580	447	**E00042580**	1.00	**447**
E00042581	261	**E00042581**	1.00	**261**
E00042582	263	**E00042582**	1.00	**263**
E00042583	174	**E00042583**	1.00	**174**
E00042584	241		0.00	**0**
E00042585	245	**E00042585**	0.29	**71**
E00042586	438	**E00042586**	0.02	**8**
E00042587	295	**E00042587**	1.00	**295**
E00042588	370	**E00042588**	1.00	**370**
E00042589	305		0.00	**0**

E00042590	271		0.00	**0**
E00042591	247		0.00	**0**
E00042592	151		0.00	**0**
E00042593	319		0.00	**0**
E00042594	208		0.00	**0**
E00042595	171		0.00	**0**
E00042596	179		0.00	**0**
E00042597	200		0.00	**0**
E00042598	315		0.00	**0**
E00042599	196		0.00	**0**
E00042600	338		0.00	**0**
E00042601	132		0.00	**0**
E00042604	545		0.00	**0**
E00042605	498		0.00	**0**
E00042606	406	**E00042606**	1.00	**406**
E00042607	383	**E00042607**	1.00	**383**
E00042608	443	**E00042608**	1.00	**443**
E00042609	496	**E00042609**	1.00	**496**
E00042610	292	**E00042610**	0.20	**57**
E00042611	344	**E00042611**	1.00	**344**
E00042612	198	**E00042612**	0.98	**195**
E00042613	329		0.00	**0**
E00042614	284	**E00042614**	0.29	**83**
E00042615	286	**E00042615**	0.70	**199**
E00042616	266		0.00	**0**
E00042617	318	**E00042617**	0.13	**41**
E00042618	220	**E00042618**	0.02	**5**
E00042619	278	**E00042619**	1.00	**278**
E00042620	258	**E00042620**	1.00	**258**
E00042621	255	**E00042621**	1.00	**255**
E00042622	297	**E00042622**	0.01	**2**
E00042623	300	**E00042623**	0.37	**112**
E00042624	339	**E00042624**	0.99	**337**
E00042625	286	**E00042625**	0.03	**9**
E00042626	358		0.00	**0**
E00042627	254	**E00042627**	0.68	**173**
E00042628	386	**E00042628**	0.80	**309**
E00042629	287	**E00042629**	1.00	**287**
E00042630	152	**E00042630**	1.00	**152**
E00042631	198	**E00042631**	1.00	**198**
E00042632	263	**E00042632**	1.00	**263**
E00042633	290		0.00	**0**
E00042634	319	**E00042634**	0.46	**148**
E00042635	219	**E00042635**	0.66	**144**
E00042636	274	**E00042636**	1.00	**274**

E00042637	534	**E00042637**	0.75	**398**
E00042638	251	**E00042638**	1.00	**251**
E00042639	250		0.00	**0**
E00042640	244		0.00	**0**
E00042641	357		0.00	**0**
E00042642	413	**E00042642**	0.99	**411**
E00042643	441	**E00042643**	0.87	**383**
E00042644	333	**E00042644**	0.99	**330**
E00042645	443	**E00042645**	1.00	**443**
E00042646	255	**E00042646**	1.00	**255**
E00042647	218	**E00042647**	0.88	**191**
E00042648	305	**E00042648**	0.29	**89**
E00042649	294	**E00042649**	0.10	**31**
E00042650	356	**E00042650**	1.00	**356**
E00042651	329	**E00042651**	0.19	**64**
E00042652	218	**E00042652**	0.79	**171**
E00042653	467	**E00042653**	1.00	**467**
E00042654	187		0.00	**0**
E00042655	247	**E00042655**	1.00	**247**
E00042656	358	**E00042656**	1.00	**358**
E00042657	408	**E00042657**	1.00	**408**
E00042658	371	**E00042658**	1.00	**371**
E00042659	373	**E00042659**	1.00	**373**
E00042661	110	**E00042661**	1.00	**110**
E00042662	300	**E00042662**	1.00	**300**
E00042663	232	**E00042663**	1.00	**232**
E00042664	269	**E00042664**	1.00	**269**
E00042665	152	**E00042665**	1.00	**152**
E00042666	334	**E00042666**	1.00	**334**
E00042667	198	**E00042667**	0.43	**85**
E00042668	281	**E00042668**	1.00	**281**
E00042669	261	**E00042669**	1.00	**261**
E00042670	369	**E00042670**	1.00	**369**
E00042671	126	**E00042671**	1.00	**126**
E00042672	1161	**E00042672**	1.00	**1161**
E00042673	340	**E00042673**	1.00	**340**
E00042674	247	**E00042674**	1.00	**247**
E00042677	244	**E00042677**	1.00	**244**
E00042679	590	**E00042679**	0.63	**369**
E00042681	365	**E00042681**	0.08	**30**
E00042682	408		0.00	**0**
E00042683	275		0.00	**0**
E00042685	120	**E00042685**	1.00	**120**
E00042686	286	**E00042686**	1.00	**286**
E00042687	306	**E00042687**	1.00	**306**

E00042688	246	**E00042688**	0.61	**149**
E00042689	341	**E00042689**	1.00	**341**
E00042690	302	**E00042690**	1.00	**302**
E00042691	205	**E00042691**	0.88	**181**
E00042693	336	**E00042693**	1.00	**336**
E00042694	225	**E00042694**	0.49	**111**
E00042695	189	**E00042695**	1.00	**189**
E00042697	337	**E00042697**	1.00	**337**
E00042702	269	**E00042702**	1.00	**269**
E00042703	250	**E00042703**	1.00	**250**
E00042704	319	**E00042704**	0.93	**298**
E00042705	260	**E00042705**	1.00	**260**
E00042706	373	**E00042706**	1.00	**373**
E00042707	416	**E00042707**	1.00	**416**
E00042708	292	**E00042708**	0.84	**245**
E00042709	332	**E00042709**	0.96	**320**
E00042710	324	**E00042710**	1.00	**324**
E00042711	236	**E00042711**	1.00	**236**
E00042712	301	**E00042712**	1.00	**301**
E00042713	510	**E00042713**	1.00	**508**
E00042714	266	**E00042714**	0.10	**28**
E00042715	292		0.00	**0**
E00042716	288		0.00	**0**
E00042717	544	**E00042717**	0.86	**466**
E00042718	260	**E00042718**	0.07	**19**
E00042719	310		0.00	**0**
E00042720	277		0.00	**0**
E00042721	376	**E00042721**	0.43	**163**
E00042722	299		0.00	**0**
E00042723	360	**E00042723**	0.33	**120**
E00042724	369		0.00	**0**
E00042725	388	**E00042725**	1.00	**388**
E00042726	324	**E00042726**	1.00	**324**
E00042727	354	**E00042727**	1.00	**354**
E00042728	354	**E00042728**	1.00	**354**
E00042729	314	**E00042729**	1.00	**314**
E00042730	338	**E00042730**	0.38	**129**
E00042731	336	**E00042731**	0.33	**110**
E00042732	244		0.00	**0**
E00042733	450		0.00	**0**
E00042734	245		0.00	**0**
E00042735	250	**E00042735**	1.00	**250**
E00042736	325		0.00	**0**
E00042737	271		0.00	**0**
E00042738	246		0.00	**0**

E00042739	319	**E00042739**	1.00	**319**
E00042740	336	**E00042740**	0.80	**270**
E00042741	324	**E00042741**	0.64	**209**
E00042742	322	**E00042742**	0.62	**199**
E00042743	311		0.00	**0**
E00042745	389	**E00042745**	0.99	**386**
E00042746	290	**E00042746**	0.60	**173**
E00042747	253	**E00042747**	0.80	**203**
E00042748	245	**E00042748**	0.13	**31**
E00042750	157	**E00042750**	0.48	**75**
E00042751	117		0.00	**0**
E00042752	119	**E00042752**	1.00	**119**
E00042753	127	**E00042753**	0.05	**6**
E00042754	225	**E00042754**	0.97	**219**
E00042755	135	**E00042755**	1.00	**135**
E00042756	302	**E00042756**	0.72	**219**
E00042757	213	**E00042757**	1.00	**213**
E00042758	298	**E00042758**	0.69	**206**
E00042759	327	**E00042759**	1.00	**327**
E00042760	342	**E00042760**	1.00	**342**
E00042761	321	**E00042761**	0.07	**22**
E00042762	280	**E00042762**	0.72	**201**
E00042763	289	**E00042763**	0.08	**23**
E00042764	384	**E00042764**	0.37	**143**
E00042765	251	**E00042765**	1.00	**251**
E00042766	268	**E00042766**	1.00	**268**
E00042767	350	**E00042767**	1.00	**350**
E00042768	241		0.00	**0**
E00042769	301	**E00042769**	0.23	**68**
E00042770	280	**E00042770**	0.59	**165**
E00042771	259	**E00042771**	0.55	**143**
E00042772	334	**E00042772**	1.00	**334**
E00042773	232	**E00042773**	0.94	**218**
E00042774	217		0.00	**0**
E00042775	356		0.00	**0**
E00042776	388	**E00042776**	0.40	**156**
E00042777	264	**E00042777**	0.45	**119**
E00042778	231	**E00042778**	1.00	**231**
E00042779	244		0.00	**0**
E00042780	298		0.00	**0**
E00042781	233	**E00042781**	1.00	**233**
E00042782	307	**E00042782**	0.01	**3**
E00042783	297		0.00	**0**
E00042784	219	**E00042784**	1.00	**219**
E00042785	231		0.00	**0**

E00042786	345	**E00042786**	0.12	**42**
E00042787	322		0.00	**0**
E00042788	266		0.00	**0**
E00042789	308	**E00042789**	0.37	**115**
E00042790	243		0.00	**0**
E00042791	300		0.00	**0**
E00042792	291	**E00042792**	0.04	**12**
E00042793	302		0.00	**0**
E00042794	366	**E00042794**	1.00	**366**
E00042795	358	**E00042795**	1.00	**358**
E00042796	279		0.00	**0**
E00042797	186		0.00	**0**
E00042798	305		0.00	**0**
E00042799	219		0.00	**0**
E00042800	237	**E00042800**	0.01	**2**
E00042801	296		0.00	**0**
E00042802	332	**E00042802**	0.16	**53**
E00042803	391	**E00042803**	0.01	**3**
E00042805	222	**E00042805**	1.00	**222**
E00042806	293	**E00042806**	1.00	**293**
E00042807	195	**E00042807**	1.00	**195**
E00042808	275	**E00042808**	0.90	**248**
E00042810	316	**E00042810**	0.87	**276**
E00042811	391	**E00042811**	1.00	**391**
E00042812	178	**E00042812**	0.99	**177**
E00042814	256	**E00042814**	1.00	**256**
E00042816	128	**E00042816**	0.93	**120**
E00042818	191	**E00042818**	1.00	**191**
E00042819	171	**E00042819**	1.00	**171**
E00042820	193		0.00	**0**
E00042822	291	**E00042822**	0.62	**181**
E00042823	285	**E00042823**	1.00	**285**
E00042824	314	**E00042824**	1.00	**314**
E00042825	363	**E00042825**	0.51	**186**
E00042826	400	**E00042826**	0.91	**365**
E00042827	402	**E00042827**	1.00	**402**
E00042828	313	**E00042828**	1.00	**313**
E00042829	316	**E00042829**	0.02	**8**
E00042830	198		0.00	**0**
E00042831	357	**E00042831**	0.94	**335**
E00042832	268	**E00042832**	0.14	**36**
E00042833	331	**E00042833**	0.48	**157**
E00042834	295	**E00042834**	0.13	**37**
E00042835	263	**E00042835**	1.00	**263**
E00042836	309	**E00042836**	1.00	**309**

E00042837	282	**E00042837**	0.05	**13**
E00042838	341		0.00	**0**
E00042839	248	**E00042839**	1.00	**248**
E00042840	224		0.00	**0**
E00042841	228	**E00042841**	0.15	**34**
E00042842	268	**E00042842**	0.33	**89**
E00042843	312	**E00042843**	1.00	**312**
E00042844	297		0.00	**0**
E00042845	245	**E00042845**	0.86	**210**
E00042846	259	**E00042846**	1.00	**259**
E00042847	296	**E00042847**	0.29	**86**
E00042848	342		0.00	**0**
E00042849	295		0.00	**0**
E00042850	256	**E00042850**	0.46	**118**
E00042851	295	**E00042851**	1.00	**295**
E00042852	353		0.00	**0**
E00042853	251	**E00042853**	0.86	**215**
E00042854	247	**E00042854**	1.00	**247**
E00042855	258	**E00042855**	1.00	**258**
E00042856	271	**E00042856**	0.98	**267**
E00042857	343	**E00042857**	1.00	**343**
E00042858	288	**E00042858**	0.86	**247**
E00042859	340	**E00042859**	0.33	**113**
E00042860	268	**E00042860**	0.46	**123**
E00042861	262	**E00042861**	0.82	**215**
E00042862	248	**E00042862**	1.00	**248**
E00042863	314	**E00042863**	1.00	**314**
E00042864	301		0.00	**0**
E00042865	327		0.00	**0**
E00042866	293		0.00	**0**
E00042867	317		0.00	**0**
E00042868	272		0.00	**0**
E00042869	319		0.00	**0**
E00042870	302		0.00	**0**
E00042871	282	**E00042871**	0.30	**84**
E00042872	280		0.00	**0**
E00042873	325	**E00042873**	0.97	**314**
E00042874	557	**E00042874**	1.00	**557**
E00042875	360	**E00042875**	1.00	**360**
E00042876	405	**E00042876**	0.53	**215**
E00042877	486	**E00042877**	1.00	**486**
E00042878	487	**E00042878**	1.00	**487**
E00042879	430	**E00042879**	1.00	**430**
E00042880	352	**E00042880**	0.12	**43**
E00042881	278	**E00042881**	0.81	**225**

E00042882	388	**E00042882**	1.00	**388**
E00042883	353	**E00042883**	0.46	**162**
E00042884	244	**E00042884**	1.00	**244**
E00042885	289	**E00042885**	0.77	**221**
E00042886	280	**E00042886**	1.00	**280**
E00042887	346	**E00042887**	1.00	**346**
E00042888	339	**E00042888**	1.00	**339**
E00042889	406	**E00042889**	0.02	**8**
E00042890	406	**E00042890**	1.00	**406**
E00042891	266	**E00042891**	0.40	**107**
E00042892	347	**E00042892**	1.00	**347**
E00042893	313	**E00042893**	0.57	**179**
E00042894	360	**E00042894**	0.99	**357**
E00042895	291		0.00	**0**
E00042896	308	**E00042896**	0.14	**43**
E00042897	398	**E00042897**	0.40	**160**
E00042898	357	**E00042898**	0.91	**324**
E00042899	493	**E00042899**	1.00	**493**
E00042900	509	**E00042900**	1.00	**509**
E00042901	360	**E00042901**	1.00	**360**
E00042902	372	**E00042902**	1.00	**372**
E00042903	374	**E00042903**	1.00	**374**
E00042904	319	**E00042904**	1.00	**319**
E00042905	200	**E00042905**	0.91	**182**
E00042906	272	**E00042906**	0.73	**198**
E00042907	311	**E00042907**	0.31	**97**
E00042908	308	**E00042908**	1.00	**308**
E00042909	264	**E00042909**	0.98	**259**
E00042910	293		0.00	**0**
E00042911	334		0.00	**0**
E00042912	495		0.00	**0**
E00042913	281		0.00	**0**
E00042914	280		0.00	**0**
E00042915	321		0.00	**0**
E00042916	387	**E00042916**	0.60	**231**
E00042917	294		0.00	**0**
E00042918	362	**E00042918**	0.13	**48**
E00042919	359	**E00042919**	1.00	**359**
E00042920	374	**E00042920**	1.00	**374**
E00042921	336	**E00042921**	0.34	**115**
E00042922	293	**E00042922**	0.23	**67**
E00042923	288	**E00042923**	0.24	**68**
E00042924	259	**E00042924**	1.00	**259**
E00042925	251	**E00042925**	1.00	**251**
E00042926	303	**E00042926**	0.97	**293**

E00042927	268	**E00042927**	1.00	**268**
E00042928	348	**E00042928**	0.18	**61**
E00042929	258		0.00	**0**
E00042930	199	**E00042930**	1.00	**199**
E00175550	249		0.00	**0**
E00175551	225	**E00175551**	0.19	**43**
E00175552	223		0.00	**0**
E00175553	236	**E00175553**	0.87	**206**
E00175554	443	**E00175554**	0.97	**432**
E00175555	417	**E00175555**	1.00	**417**
E00175556	124	**E00175556**	0.98	**122**
E00175557	144		0.00	**0**
E00175558	216	**E00175558**	0.98	**212**
E00175559	206		0.00	**0**
E00175560	202		0.00	**0**
E00175561	225	**E00175561**	1.00	**225**
E00175562	349		0.00	**0**
E00175563	192		0.00	**0**
E00175564	354	**E00175564**	0.28	**100**
E00175565	559		0.00	**0**
E00175566	241	**E00175566**	0.72	**172**
E00175567	370		0.00	**0**
E00175568	348		0.00	**0**
E00175569	371		0.00	**0**
E00175570	396		0.00	**0**
E00175571	289		0.00	**0**
E00175572	150		0.00	**0**
E00175573	330	**E00175573**	0.03	**10**
E00175574	623	**E00175574**	1.00	**623**
E00175575	194		0.00	**0**
E00175576	165		0.00	**0**
E00175577	375	**E00175577**	0.95	**356**
E00175578	891	**E00175578**	0.88	**787**
E00175579	167		0.00	**0**
E00175580	237		0.00	**0**
E00175581	261	**E00175581**	0.93	**243**
E00175582	363	**E00175582**	0.97	**352**
E00175583	239	**E00175583**	0.85	**203**
E00175584	1346		0.00	**0**
E00175585	201		0.00	**0**
E00175586	336	**E00175586**	1.00	**336**
E00175587	150		0.00	**0**
E00175588	167	**E00175588**	1.00	**167**
E00175589	500	**E00175589**	0.71	**354**
E00175590	206	**E00175590**	1.00	**206**

E00175591	265		0.00	**0**
E00175592	202		0.00	**0**
E00175593	600	**E00175593**	0.83	**497**
E00175594	282	**E00175594**	1.00	**282**
E00175595	116	**E00175595**	1.00	**116**
E00175596	279	**E00175596**	0.98	**273**
E00175597	421	**E00175597**	0.79	**332**
E00175598	612	**E00175598**	1.00	**612**
E00175599	364		0.00	**0**
E00175600	150	**E00175600**	0.07	**10**
E00175601	156		0.00	**0**
E00175602	227		0.00	**0**
E00175603	259	**E00175603**	0.58	**150**
E00175604	232		0.00	**0**
E00175605	214		0.00	**0**
Total	**280226**			**152013**

Appendix B: Application of the PWC Technique to Estimate Population of Output Areas Located inside the Merged Service Areas of All GP Practices in Newcastle

OAs in Newcastle	Population in OA	OAs with Population inside the Service Area	Weight of OA inside the Service Area	Population inside the Service Area
E00042042	268		0	**0**
E00042043	340	**E00042043**	1	**340**
E00042044	264		0	**0**
E00042045	234		0	**0**
E00042046	461	**E00042046**	1	**461**
E00042047	346	**E00042047**	1	**346**
E00042048	355	**E00042048**	1	**355**
E00042049	336		0	**0**
E00042050	388		0	**0**
E00042051	312	**E00042051**	1	**312**
E00042052	329	**E00042052**	1	**329**
E00042053	309		0	**0**
E00042054	291	**E00042054**	1	**291**
E00042055	314		0	**0**
E00042056	236	**E00042056**	1	**236**
E00042057	393	**E00042057**	1	**393**
E00042058	124	**E00042058**	1	**124**
E00042059	324	**E00042059**	1	**324**
E00042061	342	**E00042061**	1	**342**
E00042062	501	**E00042062**	1	**501**
E00042064	351	**E00042064**	1	**351**
E00042065	298	**E00042065**	1	**298**
E00042066	132	**E00042066**	1	**132**
E00042067	353		0	**0**
E00042068	320	**E00042068**	1	**320**
E00042069	334		0	**0**
E00042070	287	**E00042070**	1	**287**
E00042071	275		0	**0**
E00042072	278	**E00042072**	1	**278**
E00042073	328	**E00042073**	1	**328**
E00042074	250		0	**0**
E00042075	361		0	**0**
E00042076	371		0	**0**
E00042077	245		0	**0**
E00042078	256	**E00042078**	1	**256**
E00042079	244		0	**0**
E00042080	248	**E00042080**	1	**248**
E00042081	433		0	**0**
E00042082	296	**E00042082**	1	**296**
E00042083	313		0	**0**

E00042084	236	**E00042084**	1	**236**
E00042085	248		0	**0**
E00042086	335		0	**0**
E00042087	304	**E00042087**	1	**304**
E00042088	360	**E00042088**	1	**360**
E00042089	194	**E00042089**	1	**194**
E00042090	267	**E00042090**	1	**267**
E00042091	362	**E00042091**	1	**362**
E00042092	295		0	**0**
E00042093	253		0	**0**
E00042094	202		0	**0**
E00042095	281		0	**0**
E00042096	218		0	**0**
E00042097	396		0	**0**
E00042099	397		0	**0**
E00042100	327	**E00042100**	1	**327**
E00042101	243	**E00042101**	1	**243**
E00042102	399		0	**0**
E00042103	323	**E00042103**	1	**323**
E00042104	488	**E00042104**	1	**488**
E00042106	363	**E00042106**	1	**363**
E00042107	263		0	**0**
E00042108	310		0	**0**
E00042109	298		0	**0**
E00042110	250		0	**0**
E00042111	227	**E00042111**	1	**227**
E00042112	280	**E00042112**	1	**280**
E00042113	279		0	**0**
E00042114	256		0	**0**
E00042115	299	**E00042115**	1	**299**
E00042116	255		0	**0**
E00042117	227		0	**0**
E00042118	460		0	**0**
E00042120	342		0	**0**
E00042121	284		0	**0**
E00042122	257		0	**0**
E00042123	210		0	**0**
E00042124	206		0	**0**
E00042125	208	**E00042125**	1	**208**
E00042126	328	**E00042126**	1	**328**
E00042127	342	**E00042127**	1	**342**
E00042128	168	**E00042128**	1	**168**
E00042129	466	**E00042129**	1	**466**
E00042130	280		0	**0**
E00042131	216		0	**0**

E00042132	225	**E00042132**	1	**225**
E00042133	279	**E00042133**	1	**279**
E00042134	299	**E00042134**	1	**299**
E00042135	267		0	**0**
E00042136	285	**E00042136**	1	**285**
E00042137	245		0	**0**
E00042138	301		0	**0**
E00042139	263		0	**0**
E00042140	294	**E00042140**	1	**294**
E00042141	352	**E00042141**	1	**352**
E00042142	324		0	**0**
E00042143	299		0	**0**
E00042144	279		0	**0**
E00042145	274		0	**0**
E00042146	294		0	**0**
E00042147	526		0	**0**
E00042148	304		0	**0**
E00042149	320	**E00042149**	1	**320**
E00042150	293		0	**0**
E00042151	278		0	**0**
E00042152	321		0	**0**
E00042153	256		0	**0**
E00042154	271		0	**0**
E00042155	286		0	**0**
E00042156	216		0	**0**
E00042157	274		0	**0**
E00042158	305		0	**0**
E00042159	313		0	**0**
E00042160	297		0	**0**
E00042161	294		0	**0**
E00042162	153		0	**0**
E00042164	259		0	**0**
E00042165	278		0	**0**
E00042166	229		0	**0**
E00042168	265		0	**0**
E00042169	291	**E00042169**	1	**291**
E00042170	314	**E00042170**	1	**314**
E00042171	312		0	**0**
E00042172	228		0	**0**
E00042173	314	**E00042173**	1	**314**
E00042174	317	**E00042174**	1	**317**
E00042175	323		0	**0**
E00042176	340	**E00042176**	1	**340**
E00042177	253	**E00042177**	1	**253**
E00042178	337	**E00042178**	1	**337**

E00042179	260		0	**0**
E00042180	539		0	**0**
E00042182	385		0	**0**
E00042183	317		0	**0**
E00042184	429		0	**0**
E00042185	339		0	**0**
E00042186	189		0	**0**
E00042187	586		0	**0**
E00042188	340		0	**0**
E00042189	269		0	**0**
E00042190	355	**E00042190**	1	**355**
E00042191	256		0	**0**
E00042192	226		0	**0**
E00042193	317		0	**0**
E00042194	336		0	**0**
E00042195	351		0	**0**
E00042196	311		0	**0**
E00042197	266	**E00042197**	1	**266**
E00042198	257		0	**0**
E00042199	288	**E00042199**	1	**288**
E00042200	284	**E00042200**	1	**284**
E00042201	299		0	**0**
E00042202	331		0	**0**
E00042203	237	**E00042203**	1	**237**
E00042205	309		0	**0**
E00042206	269	**E00042206**	1	**269**
E00042207	330		0	**0**
E00042208	234		0	**0**
E00042209	276		0	**0**
E00042210	292		0	**0**
E00042211	271		0	**0**
E00042212	307		0	**0**
E00042213	452		0	**0**
E00042214	282		0	**0**
E00042215	304		0	**0**
E00042216	267		0	**0**
E00042217	326		0	**0**
E00042218	301		0	**0**
E00042219	328		0	**0**
E00042220	353		0	**0**
E00042221	200		0	**0**
E00042222	303		0	**0**
E00042223	297		0	**0**
E00042224	292		0	**0**
E00042225	291		0	**0**

E00042226	157		0	**0**
E00042227	255		0	**0**
E00042228	424	**E00042228**	1	**424**
E00042229	262	**E00042229**	1	**262**
E00042230	324		0	**0**
E00042232	325		0	**0**
E00042233	304	**E00042233**	1	**304**
E00042234	340		0	**0**
E00042235	290		0	**0**
E00042236	227	**E00042236**	1	**227**
E00042237	119	**E00042237**	1	**119**
E00042238	366		0	**0**
E00042240	287	**E00042240**	1	**287**
E00042241	252	**E00042241**	1	**252**
E00042242	277	**E00042242**	1	**277**
E00042243	257	**E00042243**	1	**257**
E00042244	329	**E00042244**	1	**329**
E00042245	451		0	**0**
E00042246	235	**E00042246**	1	**235**
E00042247	162	**E00042247**	1	**162**
E00042248	272		0	**0**
E00042249	251	**E00042249**	1	**251**
E00042250	258	**E00042250**	1	**258**
E00042251	365		0	**0**
E00042252	221		0	**0**
E00042253	260	**E00042253**	1	**260**
E00042254	282	**E00042254**	1	**282**
E00042255	326	**E00042255**	1	**326**
E00042256	323	**E00042256**	1	**323**
E00042257	267	**E00042257**	1	**267**
E00042258	289	**E00042258**	1	**289**
E00042259	294		0	**0**
E00042260	386		0	**0**
E00042261	280	**E00042261**	1	**280**
E00042262	534	**E00042262**	1	**534**
E00042263	340	**E00042263**	1	**340**
E00042264	288	**E00042264**	1	**288**
E00042265	366	**E00042265**	1	**366**
E00042266	512	**E00042266**	1	**512**
E00042267	401	**E00042267**	1	**401**
E00042268	243	**E00042268**	1	**243**
E00042269	405	**E00042269**	1	**405**
E00042270	400	**E00042270**	1	**400**
E00042271	445	**E00042271**	1	**445**
E00042272	609	**E00042272**	1	**609**

E00042273	463	**E00042273**	1	**463**
E00042274	291	**E00042274**	1	**291**
E00042275	468	**E00042275**	1	**468**
E00042276	372	**E00042276**	1	**372**
E00042277	413	**E00042277**	1	**413**
E00042278	256	**E00042278**	1	**256**
E00042279	394	**E00042279**	1	**394**
E00042280	494	**E00042280**	1	**494**
E00042281	353	**E00042281**	1	**353**
E00042282	310	**E00042282**	1	**310**
E00042283	182	**E00042283**	1	**182**
E00042284	489	**E00042284**	1	**489**
E00042285	404	**E00042285**	1	**404**
E00042286	394	**E00042286**	1	**394**
E00042287	298	**E00042287**	1	**298**
E00042288	304		0	**0**
E00042289	263	**E00042289**	1	**263**
E00042290	265	**E00042290**	1	**265**
E00042291	260	**E00042291**	1	**260**
E00042292	226		0	**0**
E00042293	292	**E00042293**	1	**292**
E00042294	278	**E00042294**	1	**278**
E00042295	369	**E00042295**	1	**369**
E00042296	256	**E00042296**	1	**256**
E00042297	289	**E00042297**	1	**289**
E00042298	235		0	**0**
E00042299	340	**E00042299**	1	**340**
E00042300	277	**E00042300**	1	**277**
E00042301	334	**E00042301**	1	**334**
E00042302	312	**E00042302**	0	**312**
E00042303	225	**E00042303**	1	**225**
E00042304	297	**E00042304**	1	**297**
E00042305	327	**E00042305**	1	**327**
E00042306	246	**E00042306**	1	**246**
E00042307	265	**E00042307**	1	**265**
E00042308	336	**E00042308**	1	**336**
E00042309	246		0	**0**
E00042310	171		0	**0**
E00042311	216		0	**0**
E00042312	262	**E00042312**	1	**262**
E00042313	301	**E00042313**	1	**301**
E00042314	267		0	**0**
E00042315	268	**E00042315**	1	**268**
E00042316	343	**E00042316**	1	**343**
E00042317	377	**E00042317**	1	**377**

E00042318	405		0	**0**
E00042319	301	**E00042319**	1	**301**
E00042320	263		0	**0**
E00042321	158	**E00042321**	1	**158**
E00042322	256	**E00042322**	1	**256**
E00042323	316	**E00042323**	1	**316**
E00042324	333	**E00042324**	1	**333**
E00042325	257	**E00042325**	1	**257**
E00042326	358		0	**0**
E00042327	270		0	**0**
E00042328	369	**E00042328**	1	**369**
E00042329	196		0	**0**
E00042330	207	**E00042330**	1	**207**
E00042331	201		0	**0**
E00042332	533		0	**0**
E00042333	289		0	**0**
E00042334	281	**E00042334**	1	**281**
E00042335	319	**E00042335**	1	**319**
E00042336	255	**E00042336**	1	**255**
E00042337	310	**E00042337**	1	**310**
E00042338	394	**E00042338**	1	**394**
E00042339	318	**E00042339**	1	**318**
E00042340	276	**E00042340**	1	**276**
E00042341	268	**E00042341**	1	**268**
E00042342	284		0	**0**
E00042343	297		0	**0**
E00042344	202	**E00042344**	1	**202**
E00042345	294	**E00042345**	1	**294**
E00042347	312	**E00042347**	1	**312**
E00042348	309	**E00042348**	1	**309**
E00042349	389	**E00042349**	1	**389**
E00042350	408		0	**0**
E00042351	281		0	**0**
E00042352	293		0	**0**
E00042353	268		0	**0**
E00042354	325	**E00042354**	1	**325**
E00042355	355	**E00042355**	1	**355**
E00042356	414	**E00042356**	1	**414**
E00042357	471	**E00042357**	1	**471**
E00042358	132		0	**0**
E00042359	165		0	**0**
E00042360	315		0	**0**
E00042361	249		0	**0**
E00042362	225		0	**0**
E00042363	294	**E00042363**	1	**294**

E00042364	266		0	**0**
E00042365	250		0	**0**
E00042366	253	**E00042366**	1	**253**
E00042367	222		0	**0**
E00042368	328		0	**0**
E00042369	220	**E00042369**	1	**220**
E00042370	267	**E00042370**	1	**267**
E00042371	306	**E00042371**	1	**306**
E00042372	259	**E00042372**	1	**259**
E00042373	360	**E00042373**	1	**360**
E00042374	310	**E00042374**	1	**310**
E00042375	277	**E00042375**	1	**277**
E00042376	240		0	**0**
E00042377	270		0	**0**
E00042378	353	**E00042378**	1	**353**
E00042379	352	**E00042379**	1	**352**
E00042380	417		0	**0**
E00042381	279	**E00042381**	1	**279**
E00042382	247	**E00042382**	1	**247**
E00042383	489		0	**0**
E00042384	392		0	**0**
E00042385	349		0	**0**
E00042386	313	**E00042386**	1	**313**
E00042387	232	**E00042387**	1	**232**
E00042388	449	**E00042388**	1	**449**
E00042389	274	**E00042389**	1	**274**
E00042390	164	**E00042390**	1	**164**
E00042391	279	**E00042391**	1	**279**
E00042392	196	**E00042392**	1	**196**
E00042393	294	**E00042393**	1	**294**
E00042394	330	**E00042394**	1	**330**
E00042395	200	**E00042395**	1	**200**
E00042396	203	**E00042396**	1	**203**
E00042397	440	**E00042397**	1	**440**
E00042398	253		0	**0**
E00042399	313		0	**0**
E00042400	353		0	**0**
E00042401	305		0	**0**
E00042402	229		0	**0**
E00042403	400		0	**0**
E00042404	352	**E00042404**	1	**352**
E00042405	268	**E00042405**	1	**268**
E00042406	578		0	**0**
E00042407	298	**E00042407**	1	**298**
E00042408	373	**E00042408**	1	**373**

E00042409	272	**E00042409**	1	**272**
E00042410	306	**E00042410**	1	**306**
E00042411	250	**E00042411**	1	**250**
E00042412	356		0	**0**
E00042413	363		0	**0**
E00042414	232	**E00042414**	1	**232**
E00042415	328	**E00042415**	1	**328**
E00042416	233	**E00042416**	1	**233**
E00042417	247	**E00042417**	1	**247**
E00042418	303	**E00042418**	1	**303**
E00042419	405	**E00042419**	1	**405**
E00042420	268	**E00042420**	1	**268**
E00042421	218	**E00042421**	1	**218**
E00042422	356	**E00042422**	1	**356**
E00042423	324		0	**0**
E00042424	310	**E00042424**	1	**310**
E00042425	328	**E00042425**	1	**328**
E00042426	326	**E00042426**	1	**326**
E00042427	388	**E00042427**	1	**388**
E00042428	344	**E00042428**	1	**344**
E00042429	323	**E00042429**	1	**323**
E00042430	244	**E00042430**	1	**244**
E00042431	249	**E00042431**	1	**249**
E00042432	362		0	**0**
E00042433	237		0	**0**
E00042434	259	**E00042434**	1	**259**
E00042435	354	**E00042435**	1	**354**
E00042436	232	**E00042436**	1	**232**
E00042437	317	**E00042437**	1	**317**
E00042438	401	**E00042438**	1	**401**
E00042439	598	**E00042439**	1	**598**
E00042440	355	**E00042440**	1	**355**
E00042441	429	**E00042441**	1	**429**
E00042442	524	**E00042442**	1	**524**
E00042443	424	**E00042443**	1	**424**
E00042444	432	**E00042444**	1	**432**
E00042445	220		0	**0**
E00042446	352	**E00042446**	1	**352**
E00042447	385	**E00042447**	1	**385**
E00042448	542	**E00042448**	1	**542**
E00042449	321	**E00042449**	1	**321**
E00042450	609	**E00042450**	1	**609**
E00042451	379	**E00042451**	1	**379**
E00042452	513		0	**0**
E00042453	286	**E00042453**	1	**286**

E00042454	340		0	**0**
E00042455	430	**E00042455**	1	**430**
E00042456	295		0	**0**
E00042457	616	**E00042457**	1	**616**
E00042458	435	**E00042458**	1	**435**
E00042459	475	**E00042459**	1	**475**
E00042460	414	**E00042460**	1	**414**
E00042461	384	**E00042461**	1	**384**
E00042462	448	**E00042462**	1	**448**
E00042463	390	**E00042463**	1	**390**
E00042464	317	**E00042464**	1	**317**
E00042465	436	**E00042465**	1	**436**
E00042466	301	**E00042466**	1	**301**
E00042467	345		0	**0**
E00042468	448	**E00042468**	1	**448**
E00042469	226	**E00042469**	1	**226**
E00042470	371	**E00042470**	1	**371**
E00042471	326	**E00042471**	1	**326**
E00042472	189		0	**0**
E00042473	349	**E00042473**	1	**349**
E00042474	237		0	**0**
E00042475	338	**E00042475**	1	**338**
E00042476	512	**E00042476**	1	**512**
E00042477	460	**E00042477**	1	**460**
E00042478	367	**E00042478**	1	**367**
E00042479	311	**E00042479**	1	**311**
E00042480	321	**E00042480**	1	**321**
E00042481	363		0	**0**
E00042482	300		0	**0**
E00042483	310		0	**0**
E00042484	271	**E00042484**	1	**271**
E00042485	302	**E00042485**	1	**302**
E00042486	222		0	**0**
E00042487	351		0	**0**
E00042488	254		0	**0**
E00042489	295	**E00042489**	1	**295**
E00042490	326		0	**0**
E00042491	509		0	**0**
E00042492	328		0	**0**
E00042493	249		0	**0**
E00042494	282		0	**0**
E00042495	193		0	**0**
E00042496	335		0	**0**
E00042498	299		0	**0**
E00042499	333		0	**0**

E00042500	401		0	**0**
E00042501	218		0	**0**
E00042502	388		0	**0**
E00042503	367	**E00042503**	1	**367**
E00042504	228		0	**0**
E00042505	260	**E00042505**	1	**260**
E00042506	167		0	**0**
E00042507	467	**E00042507**	1	**467**
E00042508	195	**E00042508**	1	**195**
E00042509	362	**E00042509**	1	**362**
E00042510	294	**E00042510**	1	**294**
E00042511	294	**E00042511**	1	**294**
E00042512	310	**E00042512**	1	**310**
E00042513	301		0	**0**
E00042514	311		0	**0**
E00042515	258		0	**0**
E00042516	363		0	**0**
E00042517	240		0	**0**
E00042518	250		0	**0**
E00042519	318		0	**0**
E00042520	265		0	**0**
E00042521	319		0	**0**
E00042522	325		0	**0**
E00042523	331		0	**0**
E00042524	288		0	**0**
E00042525	369		0	**0**
E00042526	324		0	**0**
E00042527	234		0	**0**
E00042528	317		0	**0**
E00042529	237		0	**0**
E00042530	289		0	**0**
E00042531	260		0	**0**
E00042532	293		0	**0**
E00042533	269		0	**0**
E00042534	247		0	**0**
E00042535	266		0	**0**
E00042536	287		0	**0**
E00042537	307		0	**0**
E00042538	287		0	**0**
E00042539	256		0	**0**
E00042540	262		0	**0**
E00042541	278		0	**0**
E00042542	273		0	**0**
E00042543	266		0	**0**
E00042544	285		0	**0**

E00042545	288		0	**0**
E00042546	272		0	**0**
E00042547	394		0	**0**
E00042548	270		0	**0**
E00042549	386	**E00042549**	1	**386**
E00042550	318	**E00042550**	1	**318**
E00042551	296	**E00042551**	1	**296**
E00042552	170	**E00042552**	1	**170**
E00042553	342	**E00042553**	1	**342**
E00042554	286	**E00042554**	1	**286**
E00042555	380	**E00042555**	1	**380**
E00042556	238		0	**0**
E00042557	306	**E00042557**	1	**306**
E00042558	200	**E00042558**	1	**200**
E00042559	354		0	**0**
E00042560	325		0	**0**
E00042561	254		0	**0**
E00042562	290		0	**0**
E00042563	281		0	**0**
E00042564	307		0	**0**
E00042565	199		0	**0**
E00042566	327		0	**0**
E00042567	282		0	**0**
E00042568	246		0	**0**
E00042569	215		0	**0**
E00042570	349		0	**0**
E00042571	210		0	**0**
E00042572	304	**E00042572**	1	**304**
E00042573	203	**E00042573**	1	**203**
E00042574	328	**E00042574**	1	**328**
E00042575	308	**E00042575**	1	**308**
E00042576	376		1	**0**
E00042577	274		0	**0**
E00042578	313		0	**0**
E00042579	196	**E00042579**	1	**196**
E00042580	447	**E00042580**	1	**447**
E00042581	261	**E00042581**	1	**261**
E00042582	263	**E00042582**	1	**263**
E00042583	174	**E00042583**	1	**174**
E00042584	241		0	**0**
E00042585	245		0	**0**
E00042586	438		0	**0**
E00042587	295	**E00042587**	1	**295**
E00042588	370	**E00042588**	1	**370**
E00042589	305		0	**0**

E00042590	271		0	**0**
E00042591	247		0	**0**
E00042592	151		0	**0**
E00042593	319		0	**0**
E00042594	208		0	**0**
E00042595	171		0	**0**
E00042596	179		0	**0**
E00042597	200		0	**0**
E00042598	315		0	**0**
E00042599	196		0	**0**
E00042600	338		0	**0**
E00042601	132		0	**0**
E00042604	545		0	**0**
E00042605	498		0	**0**
E00042606	406	**E00042606**	1	**406**
E00042607	383	**E00042607**	1	**383**
E00042608	443	**E00042608**	1	**443**
E00042609	496	**E00042609**	1	**496**
E00042610	292		0	**0**
E00042611	344	**E00042611**	1	**344**
E00042612	198	**E00042612**	1	**198**
E00042613	329		0	**0**
E00042614	284		0	**0**
E00042615	286	**E00042615**	1	**286**
E00042616	266		0	**0**
E00042617	318		0	**0**
E00042618	220		0	**0**
E00042619	278	**E00042619**	1	**278**
E00042620	258	**E00042620**	1	**258**
E00042621	255	**E00042621**	1	**255**
E00042622	297		0	**0**
E00042623	300	**E00042623**	1	**300**
E00042624	339	**E00042624**	1	**339**
E00042625	286		0	**0**
E00042626	358		0	**0**
E00042627	254	**E00042627**	1	**254**
E00042628	386	**E00042628**	1	**386**
E00042629	287	**E00042629**	1	**287**
E00042630	152	**E00042630**	1	**152**
E00042631	198	**E00042631**	1	**198**
E00042632	263	**E00042632**	1	**263**
E00042633	290		0	**0**
E00042634	319	**E00042634**	1	**319**
E00042635	219	**E00042635**	1	**219**
E00042636	274	**E00042636**	1	**274**

E00042637	534	**E00042637**	1	**534**
E00042638	251	**E00042638**	1	**251**
E00042639	250		0	**0**
E00042640	244		0	**0**
E00042641	357		0	**0**
E00042642	413	**E00042642**	1	**413**
E00042643	441	**E00042643**	1	**441**
E00042644	333	**E00042644**	1	**333**
E00042645	443	**E00042645**	1	**443**
E00042646	255	**E00042646**	1	**255**
E00042647	218	**E00042647**	1	**218**
E00042648	305		0	**0**
E00042649	294		0	**0**
E00042650	356	**E00042650**	1	**356**
E00042651	329		0	**0**
E00042652	218	**E00042652**	1	**218**
E00042653	467	**E00042653**	1	**467**
E00042654	187		0	**0**
E00042655	247	**E00042655**	1	**247**
E00042656	358	**E00042656**	1	**358**
E00042657	408	**E00042657**	1	**408**
E00042658	371	**E00042658**	1	**371**
E00042659	373	**E00042659**	1	**373**
E00042661	110	**E00042661**	1	**110**
E00042662	300	**E00042662**	1	**300**
E00042663	232	**E00042663**	1	**232**
E00042664	269	**E00042664**	1	**269**
E00042665	152	**E00042665**	1	**152**
E00042666	334	**E00042666**	1	**334**
E00042667	198	**E00042667**	1	**198**
E00042668	281	**E00042668**	1	**281**
E00042669	261	**E00042669**	1	**261**
E00042670	369	**E00042670**	1	**369**
E00042671	126	**E00042671**	1	**126**
E00042672	1161	**E00042672**	1	**1161**
E00042673	340	**E00042673**	1	**340**
E00042674	247	**E00042674**	1	**247**
E00042677	244	**E00042677**	1	**244**
E00042679	590	**E00042679**	1	**590**
E00042681	365		0	**0**
E00042682	408		0	**0**
E00042683	275		0	**0**
E00042685	120	**E00042685**	1	**120**
E00042686	286	**E00042686**	1	**286**
E00042687	306	**E00042687**	1	**306**

E00042688	246	**E00042688**	1	**246**
E00042689	341	**E00042689**	1	**341**
E00042690	302	**E00042690**	1	**302**
E00042691	205	**E00042691**	1	**205**
E00042693	336	**E00042693**	1	**336**
E00042694	225		0	**0**
E00042695	189	**E00042695**	1	**189**
E00042697	337	**E00042697**	1	**337**
E00042702	269	**E00042702**	1	**269**
E00042703	250	**E00042703**	1	**250**
E00042704	319	**E00042704**	1	**319**
E00042705	260	**E00042705**	1	**260**
E00042706	373	**E00042706**	1	**373**
E00042707	416	**E00042707**	1	**416**
E00042708	292	**E00042708**	1	**292**
E00042709	332	**E00042709**	1	**332**
E00042710	324	**E00042710**	1	**324**
E00042711	236	**E00042711**	1	**236**
E00042712	301	**E00042712**	1	**301**
E00042713	510	**E00042713**	1	**510**
E00042714	266		0	**0**
E00042715	292		0	**0**
E00042716	288		0	**0**
E00042717	544	**E00042717**	1	**544**
E00042718	260		0	**0**
E00042719	310		0	**0**
E00042720	277		0	**0**
E00042721	376		0	**0**
E00042722	299		0	**0**
E00042723	360		0	**0**
E00042724	369		0	**0**
E00042725	388	**E00042725**	1	**388**
E00042726	324	**E00042726**	1	**324**
E00042727	354	**E00042727**	1	**354**
E00042728	354	**E00042728**	1	**354**
E00042729	314	**E00042729**	1	**314**
E00042730	338	**E00042730**	1	**338**
E00042731	336		0	**0**
E00042732	244		0	**0**
E00042733	450		0	**0**
E00042734	245		0	**0**
E00042735	250	**E00042735**	1	**250**
E00042736	325		0	**0**
E00042737	271		0	**0**
E00042738	246		0	**0**

E00042739	319	**E00042739**	1	**319**
E00042740	336	**E00042740**	1	**336**
E00042741	324		0	**0**
E00042742	322	**E00042742**	1	**322**
E00042743	311		0	**0**
E00042745	389	**E00042745**	1	**389**
E00042746	290		0	**0**
E00042747	253	**E00042747**	1	**253**
E00042748	245		0	**0**
E00042750	157	**E00042750**	1	**157**
E00042751	117		0	**0**
E00042752	119	**E00042752**	1	**119**
E00042753	127		0	**0**
E00042754	225	**E00042754**	1	**225**
E00042755	135	**E00042755**	1	**135**
E00042756	302	**E00042756**	1	**302**
E00042757	213	**E00042757**	1	**213**
E00042758	298		0	**0**
E00042759	327	**E00042759**	1	**327**
E00042760	342	**E00042760**	1	**342**
E00042761	321		0	**0**
E00042762	280		0	**0**
E00042763	289		0	**0**
E00042764	384		0	**0**
E00042765	251	**E00042765**	1	**251**
E00042766	268	**E00042766**	1	**268**
E00042767	350	**E00042767**	1	**350**
E00042768	241		0	**0**
E00042769	301		0	**0**
E00042770	280		0	**0**
E00042771	259	**E00042771**	1	**259**
E00042772	334	**E00042772**	1	**334**
E00042773	232	**E00042773**	1	**232**
E00042774	217		0	**0**
E00042775	356		0	**0**
E00042776	388		0	**0**
E00042777	264		0	**0**
E00042778	231	**E00042778**	1	**231**
E00042779	244		0	**0**
E00042780	298		0	**0**
E00042781	233	**E00042781**	1	**233**
E00042782	307		0	**0**
E00042783	297		0	**0**
E00042784	219	**E00042784**	1	**219**
E00042785	231		0	**0**

E00042786	345		0	**0**
E00042787	322		0	**0**
E00042788	266		0	**0**
E00042789	308		0	**0**
E00042790	243		0	**0**
E00042791	300		0	**0**
E00042792	291		0	**0**
E00042793	302		0	**0**
E00042794	366	**E00042794**	1	**366**
E00042795	358	**E00042795**	1	**358**
E00042796	279		0	**0**
E00042797	186		0	**0**
E00042798	305		0	**0**
E00042799	219		0	**0**
E00042800	237		0	**0**
E00042801	296		0	**0**
E00042802	332		0	**0**
E00042803	391		0	**0**
E00042805	222	**E00042805**	1	**222**
E00042806	293	**E00042806**	1	**293**
E00042807	195	**E00042807**	1	**195**
E00042808	275	**E00042808**	1	**275**
E00042810	316	**E00042810**	1	**316**
E00042811	391	**E00042811**	1	**391**
E00042812	178	**E00042812**	1	**178**
E00042814	256	**E00042814**	1	**256**
E00042816	128	**E00042816**	1	**128**
E00042818	191	**E00042818**	1	**191**
E00042819	171	**E00042819**	1	**171**
E00042820	193		0	**0**
E00042822	291		0	**0**
E00042823	285	**E00042823**	1	**285**
E00042824	314	**E00042824**	1	**314**
E00042825	363		0	**0**
E00042826	400	**E00042826**	1	**400**
E00042827	402	**E00042827**	1	**402**
E00042828	313	**E00042828**	1	**313**
E00042829	316		0	**0**
E00042830	198		0	**0**
E00042831	357	**E00042831**	1	**357**
E00042832	268		0	**0**
E00042833	331		0	**0**
E00042834	295		0	**0**
E00042835	263	**E00042835**	1	**263**
E00042836	309	**E00042836**	1	**309**

E00042837	282		0	**0**
E00042838	341		0	**0**
E00042839	248	**E00042839**	1	**248**
E00042840	224		0	**0**
E00042841	228		0	**0**
E00042842	268	**E00042842**	1	**268**
E00042843	312	**E00042843**	1	**312**
E00042844	297		0	**0**
E00042845	245	**E00042845**	1	**245**
E00042846	259	**E00042846**	1	**259**
E00042847	296		0	**0**
E00042848	342		0	**0**
E00042849	295		0	**0**
E00042850	256		0	**0**
E00042851	295	**E00042851**	1	**295**
E00042852	353		0	**0**
E00042853	251	**E00042853**	1	**251**
E00042854	247	**E00042854**	1	**247**
E00042855	258	**E00042855**	1	**258**
E00042856	271	**E00042856**	1	**271**
E00042857	343	**E00042857**	1	**343**
E00042858	288	**E00042858**	1	**288**
E00042859	340		0	**0**
E00042860	268	**E00042860**	1	**268**
E00042861	262	**E00042861**	1	**262**
E00042862	248	**E00042862**	1	**248**
E00042863	314	**E00042863**	1	**314**
E00042864	301		0	**0**
E00042865	327		0	**0**
E00042866	293		0	**0**
E00042867	317		0	**0**
E00042868	272		0	**0**
E00042869	319		0	**0**
E00042870	302		0	**0**
E00042871	282		0	**0**
E00042872	280		0	**0**
E00042873	325	**E00042873**	1	**325**
E00042874	557	**E00042874**	1	**557**
E00042875	360	**E00042875**	1	**360**
E00042876	405		0	**0**
E00042877	486	**E00042877**	1	**486**
E00042878	487	**E00042878**	1	**487**
E00042879	430	**E00042879**	1	**430**
E00042880	352		0	**0**
E00042881	278	**E00042881**	1	**278**

E00042882	388	**E00042882**	1	**388**
E00042883	353		0	**0**
E00042884	244	**E00042884**	1	**244**
E00042885	289	**E00042885**	1	**289**
E00042886	280	**E00042886**	1	**280**
E00042887	346	**E00042887**	1	**346**
E00042888	339	**E00042888**	1	**339**
E00042889	406		0	**0**
E00042890	406	**E00042890**	1	**406**
E00042891	266		0	**0**
E00042892	347	**E00042892**	1	**347**
E00042893	313	**E00042893**	1	**313**
E00042894	360	**E00042894**	1	**360**
E00042895	291		0	**0**
E00042896	308		0	**0**
E00042897	398		0	**0**
E00042898	357	**E00042898**	1	**357**
E00042899	493	**E00042899**	1	**493**
E00042900	509	**E00042900**	1	**509**
E00042901	360	**E00042901**	1	**360**
E00042902	372	**E00042902**	1	**372**
E00042903	374	**E00042903**	1	**374**
E00042904	319	**E00042904**	1	**319**
E00042905	200	**E00042905**	1	**200**
E00042906	272	**E00042906**	1	**272**
E00042907	311		0	**0**
E00042908	308	**E00042908**	1	**308**
E00042909	264		0	**0**
E00042910	293		0	**0**
E00042911	334		0	**0**
E00042912	495		0	**0**
E00042913	281		0	**0**
E00042914	280		0	**0**
E00042915	321		0	**0**
E00042916	387	**E00042916**	1	**387**
E00042917	294		0	**0**
E00042918	362		0	**0**
E00042919	359	**E00042919**	1	**359**
E00042920	374	**E00042920**	1	**374**
E00042921	336		0	**0**
E00042922	293		0	**0**
E00042923	288		0	**0**
E00042924	259	**E00042924**	1	**259**
E00042925	251	**E00042925**	1	**251**
E00042926	303	**E00042926**	1	**303**

E00042927	268	**E00042927**	1	**268**
E00042928	348		0	**0**
E00042929	258		0	**0**
E00042930	199	**E00042930**	1	**199**
E00175550	249		0	**0**
E00175551	225		0	**0**
E00175552	223		0	**0**
E00175553	236	**E00175553**	1	**236**
E00175554	443	**E00175554**	1	**443**
E00175555	417	**E00175555**	1	**417**
E00175556	124	**E00175556**	1	**124**
E00175557	144		0	**0**
E00175558	216	**E00175558**	1	**216**
E00175559	206		0	**0**
E00175560	202		0	**0**
E00175561	225	**E00175561**	1	**225**
E00175562	349		0	**0**
E00175563	192		0	**0**
E00175564	354		0	**0**
E00175565	559		0	**0**
E00175566	241	**E00175566**	1	**241**
E00175567	370		0	**0**
E00175568	348		0	**0**
E00175569	371		0	**0**
E00175570	396		0	**0**
E00175571	289		0	**0**
E00175572	150		0	**0**
E00175573	330		0	**0**
E00175574	623	**E00175574**	1	**623**
E00175575	194		0	**0**
E00175576	165		0	**0**
E00175577	375	**E00175577**	1	**375**
E00175578	891	**E00175578**	1	**891**
E00175579	167		0	**0**
E00175580	237		0	**0**
E00175581	261	**E00175581**	1	**261**
E00175582	363	**E00175582**	1	**363**
E00175583	239	**E00175583**	1	**239**
E00175584	1346		0	**0**
E00175585	201		0	**0**
E00175586	336	**E00175586**	1	**336**
E00175587	150		0	**0**
E00175588	167	**E00175588**	1	**167**
E00175589	500		0	**0**
E00175590	206	**E00175590**	1	**206**

E00175591	265		0	**0**
E00175592	202		0	**0**
E00175593	600		0	**0**
E00175594	282	**E00175594**	1	**282**
E00175595	116	**E00175595**	1	**116**
E00175596	279	**E00175596**	1	**279**
E00175597	421	**E00175597**	1	**421**
E00175598	612	**E00175598**	1	**612**
E00175599	364		0	**0**
E00175600	150		0	**0**
E00175601	156		0	**0**
E00175602	227		0	**0**
E00175603	259	**E00175603**	1	**259**
E00175604	232		0	**0**
E00175605	214		0	**0**
Total	**280266**			**150975**

Appendix C: The Difference in the Weights Assigned to the Output Areas
Based on Scenario One and Two between the Application of the HSW and PWC Techniques

No.	OA Code 1	Weight 1_ OA with Partial Population inside the Service Areas_HSW	Weight 2_ OA with Total Population inside the Service Areas_PWC	Difference of Weight 2 to 1	OA Code 2	Weight 1_ OA with Partial Population inside the Service Areas_HSW	Weight 3_ OA with No Population inside the Service Areas_PWC	Difference of Weight 1 to 3
1	E00042043	0.5	1	**0.5**	E00042042	0.4	0	**0.4**
2	E00042046	0.8	1	**0.2**	E00042044	0.3	0	**0.3**
3	E00042048	0.7	1	**0.3**	E00042045	0.8	0	**0.8**
4	E00042052	0.7	1	**0.3**	E00042053	0.2	0	**0.2**
5	E00042056	0.9	1	**0.1**	E00042069	0.3	0	**0.3**
6	E00042057	0.7	1	**0.3**	E00042071	0.4	0	**0.4**
7	E00042070	0.8	1	**0.2**	E00042077	0.1	0	**0.1**
8	E00042073	0.4	1	**0.6**	E00042079	0.1	0	**0.1**
9	E00042078	0.7	1	**0.3**	E00042086	0.6	0	**0.6**
10	E00042082	0.9	1	**0.1**	E00042107	0.3	0	**0.3**
11	E00042084	0.7	1	**0.3**	E00042108	0.1	0	**0.1**
12	E00042087	0.6	1	**0.4**	E00042114	0.1	0	**0.1**
13	E00042089	0.8	1	**0.2**	E00042120	0.1	0	**0.1**
14	E00042090	0.6	1	**0.4**	E00042122	0.1	0	**0.1**
15	E00042091	0.9	1	**0.1**	E00042130	0.1	0	**0.1**
16	E00042115	0.6	1	**0.4**	E00042131	0.2	0	**0.2**
17	E00042126	0.9	1	**0.1**	E00042150	0.1	0	**0.1**
18	E00042133	0.4	1	**0.6**	E00042151	0.1	0	**0.1**
19	E00042140	0.7	1	**0.3**	E00042175	0.2	0	**0.2**
20	E00042141	0.7	1	**0.3**	E00042179	0.3	0	**0.3**
21	E00042149	0.6	1	**0.4**	E00042188	0.4	0	**0.4**
22	E00042177	0.7	1	**0.3**	E00042194	0.1	0	**0.1**

23	E00042178	0.7	1	**0.3**	E00042195	0.1	0	**0.1**
24	E00042197	0.9	1	**0.1**	E00042214	0.5	0	**0.5**
25	E00042199	0.9	1	**0.1**	E00042216	0.4	0	**0.4**
26	E00042203	0.7	1	**0.3**	E00042234	0.1	0	**0.1**
27	E00042228	0.4	1	**0.6**	E00042235	0.2	0	**0.2**
28	E00042236	0.6	1	**0.4**	E00042238	0.4	0	**0.4**
29	E00042237	0.7	1	**0.3**	E00042245	0.1	0	**0.1**
30	E00042241	0.4	1	**0.6**	E00042248	0.2	0	**0.2**
31	E00042242	0.7	1	**0.3**	E00042251	0.1	0	**0.1**
32	E00042243	0.8	1	**0.2**	E00042259	0.2	0	**0.2**
33	E00042244	0.3	1	**0.7**	E00042298	0.1	0	**0.1**
34	E00042246	0.8	1	**0.2**	E00042311	0.2	0	**0.2**
35	E00042255	0.7	1	**0.3**	E00042314	0.2	0	**0.2**
36	E00042256	0.9	1	**0.1**	E00042318	0.4	0	**0.4**
37	E00042257	0.8	1	**0.2**	E00042320	0.4	0	**0.4**
38	E00042268	0.6	1	**0.4**	E00042329	0.1	0	**0.1**
39	E00042289	0.5	1	**0.5**	E00042333	0.1	0	**0.1**
40	E00042290	0.9	1	**0.1**	E00042342	0.1	0	**0.1**
41	E00042291	0.5	1	**0.5**	E00042350	0.5	0	**0.5**
42	E00042302	0.7	1	**0.3**	E00042351	0.5	0	**0.5**
43	E00042305	0.4	1	**0.6**	E00042352	0.3	0	**0.3**
44	E00042312	0.5	1	**0.5**	E00042361	0.3	0	**0.3**
45	E00042313	0.9	1	**0.1**	E00042364	0.2	0	**0.2**
46	E00042315	0.6	1	**0.4**	E00042367	0.1	0	**0.1**
47	E00042328	0.6	1	**0.4**	E00042383	0.3	0	**0.3**
48	E00042330	0.8	1	**0.2**	E00042385	0.1	0	**0.1**
49	E00042334	0.5	1	**0.5**	E00042400	0.5	0	**0.5**
50	E00042337	0.8	1	**0.2**	E00042403	0.2	0	**0.2**
51	E00042341	0.8	1	**0.2**	E00042406	0.4	0	**0.4**
52	E00042344	0.9	1	**0.1**	E00042412	0.4	0	**0.4**

53	E00042345	0.9	1	**0.1**	E00042413	0.4	0	**0.4**
54	E00042347	0.9	1	**0.1**	E00042423	0.2	0	**0.2**
55	E00042348	0.8	1	**0.2**	E00042432	0.4	0	**0.4**
56	E00042349	0.7	1	**0.3**	E00042433	0.1	0	**0.1**
57	E00042366	0.2	1	**0.8**	E00042445	0.5	0	**0.5**
58	E00042369	0.8	1	**0.2**	E00042452	0.4	0	**0.4**
59	E00042386	0.8	1	**0.2**	E00042454	0.3	0	**0.3**
60	E00042387	0.8	1	**0.2**	E00042456	0.4	0	**0.4**
61	E00042393	0.7	1	**0.3**	E00042467	0.4	0	**0.4**
62	E00042408	0.9	1	**0.1**	E00042472	0.4	0	**0.4**
63	E00042410	0.8	1	**0.2**	E00042474	0.2	0	**0.2**
64	E00042414	0.7	1	**0.3**	E00042481	0.2	0	**0.2**
65	E00042415	0.5	1	**0.5**	E00042483	0.5	0	**0.5**
66	E00042416	0.9	1	**0.1**	E00042487	0.1	0	**0.1**
67	E00042417	0.6	1	**0.4**	E00042488	0.1	0	**0.1**
68	E00042422	0.9	1	**0.1**	E00042493	0.3	0	**0.3**
69	E00042430	0.6	1	**0.4**	E00042513	0.1	0	**0.1**
70	E00042440	0.7	1	**0.3**	E00042540	0.1	0	**0.1**
71	E00042441	0.7	1	**0.3**	E00042559	0.2	0	**0.2**
72	E00042443	0.9	1	**0.1**	E00042570	0.2	0	**0.2**
73	E00042459	0.9	1	**0.1**	E00042571	0.1	0	**0.1**
74	E00042460	0.8	1	**0.2**	E00042576	0.3	0	**0.3**
75	E00042464	0.8	1	**0.2**	E00042578	0.3	0	**0.3**
76	E00042465	0.9	1	**0.1**	E00042585	0.3	0	**0.3**
77	E00042468	0.9	1	**0.1**	E00042610	0.2	0	**0.2**
78	E00042470	0.9	1	**0.1**	E00042614	0.3	0	**0.3**
79	E00042489	0.8	1	**0.2**	E00042617	0.1	0	**0.1**
80	E00042507	0.9	1	**0.1**	E00042648	0.3	0	**0.3**
81	E00042511	0.5	1	**0.5**	E00042649	0.1	0	**0.1**
82	E00042549	0.6	1	**0.4**	E00042651	0.2	0	**0.2**

83	E00042552	0.9	1	**0.1**	E00042681	0.1	0	**0.1**
84	E00042554	0.7	1	**0.3**	E00042694	0.5	0	**0.5**
85	E00042572	0.9	1	**0.1**	E00042714	0.1	0	**0.1**
86	E00042615	0.7	1	**0.3**	E00042718	0.1	0	**0.1**
87	E00042623	0.4	1	**0.6**	E00042721	0.4	0	**0.4**
88	E00042627	0.7	1	**0.3**	E00042723	0.3	0	**0.3**
89	E00042628	0.8	1	**0.2**	E00042731	0.3	0	**0.3**
90	E00042634	0.5	1	**0.5**	E00042741	0.6	0	**0.6**
91	E00042635	0.7	1	**0.3**	E00042746	0.6	0	**0.6**
92	E00042637	0.7	1	**0.3**	E00042748	0.1	0	**0.1**
93	E00042643	0.9	1	**0.1**	E00042753	0.1	0	**0.1**
94	E00042647	0.9	1	**0.1**	E00042758	0.7	0	**0.7**
95	E00042652	0.8	1	**0.2**	E00042761	0.1	0	**0.1**
96	E00042667	0.4	1	**0.6**	E00042762	0.7	0	**0.7**
97	E00042679	0.6	1	**0.4**	E00042763	0.1	0	**0.1**
98	E00042688	0.6	1	**0.4**	E00042764	0.4	0	**0.4**
99	E00042691	0.9	1	**0.1**	E00042769	0.2	0	**0.2**
100	E00042704	0.9	1	**0.1**	E00042770	0.6	0	**0.6**
101	E00042708	0.8	1	**0.2**	E00042777	0.5	0	**0.5**
102	E00042717	0.9	1	**0.1**	E00042786	0.1	0	**0.1**
103	E00042730	0.4	1	**0.6**	E00042789	0.4	0	**0.4**
104	E00042740	0.8	1	**0.2**	E00042802	0.2	0	**0.2**
105	E00042742	0.6	1	**0.4**	E00042822	0.6	0	**0.6**
106	E00042747	0.8	1	**0.2**	E00042825	0.5	0	**0.5**
107	E00042750	0.5	1	**0.5**	E00042832	0.1	0	**0.1**
108	E00042756	0.7	1	**0.3**	E00042833	0.5	0	**0.5**
109	E00042771	0.6	1	**0.4**	E00042834	0.1	0	**0.1**
110	E00042773	0.9	1	**0.1**	E00042841	0.2	0	**0.2**
111	E00042808	0.9	1	**0.1**	E00042847	0.3	0	**0.3**
112	E00042810	0.9	1	**0.1**	E00042850	0.5	0	**0.5**

113	E00042816	0.9	1	**0.1**	E00042859	0.3	0	**0.3**
114	E00042826	0.9	1	**0.1**	E00042871	0.3	0	**0.3**
115	E00042831	0.9	1	**0.1**	E00042876	0.5	0	**0.5**
116	E00042842	0.3	1	**0.7**	E00042880	0.1	0	**0.1**
117	E00042845	0.9	1	**0.1**	E00042883	0.5	0	**0.5**
118	E00042853	0.9	1	**0.1**	E00042891	0.4	0	**0.4**
119	E00042858	0.9	1	**0.1**	E00042896	0.1	0	**0.1**
120	E00042860	0.5	1	**0.5**	E00042897	0.4	0	**0.4**
121	E00042861	0.8	1	**0.2**	E00042907	0.3	0	**0.3**
122	E00042881	0.8	1	**0.2**	E00042918	0.1	0	**0.1**
123	E00042885	0.8	1	**0.2**	E00042921	0.3	0	**0.3**
124	E00042893	0.6	1	**0.4**	E00042922	0.2	0	**0.2**
125	E00042898	0.9	1	**0.1**	E00042923	0.2	0	**0.2**
126	E00042905	0.9	1	**0.1**	E00042928	0.2	0	**0.2**
127	E00042906	0.7	1	**0.3**	E00175551	0.2	0	**0.2**
128	E00042916	0.6	1	**0.4**	E00175564	0.3	0	**0.3**
129	E00175553	0.9	1	**0.1**	E00175589	0.7	0	**0.7**
130	E00175566	0.7	1	**0.3**	E00175593	0.8	0	**0.8**
131	E00175577	0.9	1	**0.1**	E00175600	0.1	0	**0.1**
132	E00175578	0.9	1	**0.1**				
133	E00175581	0.9	1	**0.1**				
134	E00175583	0.9	1	**0.1**				
135	E00175597	0.8	1	**0.2**				
136	E00175603	0.6	1	**0.4**				

Appendix D: The Calculation Process of the Number of Residents and Social Groups with Potential Accessibility to All GP Practices by Service Area in Newcastle Applying the HSW Method

OA Code	No. of Household Space in Overlap	No. of Household Space in OA	Weight of OA with Access	No. of Resident	No. of Resident with Access	No. of Deprived Household	No. of Deprived Household with Access	No. of Non-Deprived Household	No. of Non-Deprived Household with Access	No. of Heavy User Group	No. of Heavy User Group with Access	No. of Light User Group	No. of Light User Group with Access
Service Area 1													
E00042579	180	180	**1.00**	152	**152**	117	**117**	35	**35**	9	**9**	187	**187**
E00042580	265	348	**0.76**	184	**140**	98	**75**	86	**65**	5	**4**	442	**337**
E00042583	20	59	**0.34**	60	**20**	35	**12**	25	**8**	5	**2**	169	**57**
E00042609	136	136	**1.00**	149	**149**	65	**65**	84	**84**	24	**24**	472	**472**
E00042822	99	159	**0.62**	151	**94**	95	**59**	56	**35**	2	**1**	289	**180**
E00042826	127	139	**0.91**	242	**221**	148	**135**	94	**86**	7	**6**	393	**359**
E00042829	8	333	**0.02**	230	**6**	145	**3**	85	**2**	9	**0**	307	**7**
E00175551	32	166	**0.19**	128	**25**	67	**13**	61	**12**	10	**2**	215	**41**
E00175553	163	187	**0.87**	121	**105**	80	**70**	41	**36**	1	**1**	235	**205**
E00175558	108	110	**0.98**	121	**119**	68	**67**	53	**52**	6	**6**	210	**206**
E00175561	166	166	**1.00**	139	**139**	112	**112**	27	**27**	2	**2**	223	**223**
Subtotal 1				1677	**1170**	1030	**728**	647	**442**	80	**57**	3142	**2275**
Service Area 2													
E00042579	180	180	**1.00**	152	**152**	117	**117**	35	**35**	9	**9**	187	**187**
E00042580	224	348	**0.64**	184	**118**	98	**63**	86	**55**	5	**3**	442	**285**
E00042583	59	59	**1.00**	60	**60**	35	**35**	25	**25**	5	**5**	169	**169**
E00042609	20	136	**0.15**	149	**22**	65	**10**	84	**12**	24	**4**	472	**69**
E00042670	28	152	**0.18**	146	**27**	111	**20**	35	**6**	40	**7**	329	**61**
E00042671	89	89	**1.00**	88	**88**	63	**63**	25	**25**	16	**16**	110	**110**
E00042672	47	95	**0.49**	90	**45**	71	**35**	19	**9**	13	**6**	1148	**568**
E00042673	170	177	**0.96**	173	**166**	117	**112**	56	**54**	25	**24**	315	**303**
E00042679	72	115	**0.63**	108	**68**	71	**44**	37	**23**	1	**1**	589	**369**
E00175551	17	166	**0.10**	128	**13**	67	**7**	61	**6**	10	**1**	215	**22**
E00175553	22	187	**0.12**	121	**14**	80	**9**	41	**5**	1	**0**	235	**28**

E00175558	41	110	**0.37**	121	**45**	68	**25**	53	**20**	6	**2**	210	**78**
E00175561	166	166	**1.00**	139	**139**	112	**112**	27	**27**	2	**2**	223	**223**
E00175564	21	74	**0.28**	72	**20**	38	**11**	34	**10**	3	**1**	351	**100**
E00175574	44	44	**1.00**	63	**63**	31	**31**	32	**32**	2	**2**	621	**621**
E00175578	6	60	**0.10**	110	**11**	81	**8**	29	**3**	9	**1**	882	**88**
E00175593	208	251	**0.83**	110	**91**	55	**46**	55	**46**	2	**2**	598	**496**
E00175595	64	64	**1.00**	62	**62**	48	**48**	14	**14**	0	**0**	116	**116**
Subtotal 2				2076	**1205**	1328	**797**	748	**407**	173	**86**	7212	**3891**
Service Area 3													
E00042058	15	48	**0.31**	48	**15**	34	**11**	14	**4**	13	**4**	111	**35**
E00042691	13	77	**0.17**	85	**14**	76	**13**	9	**2**	33	**6**	172	**29**
E00042693	106	117	**0.91**	145	**131**	122	**111**	23	**21**	52	**47**	284	**257**
E00042694	9	89	**0.10**	85	**9**	72	**7**	13	**1**	43	**4**	182	**18**
E00042697	155	155	**1.00**	157	**157**	131	**131**	26	**26**	75	**75**	262	**262**
E00175554	96	193	**0.50**	181	**90**	135	**67**	46	**23**	56	**28**	387	**192**
E00175581	123	132	**0.93**	129	**120**	106	**99**	23	**21**	28	**26**	233	**217**
E00175586	125	125	**1.00**	119	**119**	95	**95**	24	**24**	62	**62**	274	**274**
E00175597	53	165	**0.32**	147	**47**	101	**32**	46	**15**	36	**12**	385	**124**
Subtotal 3				1096	**703**	872	**566**	224	**137**	398	**264**	2290	**1409**
Service Area 4													
E00042042	43	115	**0.37**	111	**42**	97	**36**	14	**5**	33	**12**	235	**88**
E00042044	35	117	**0.30**	117	**35**	74	**22**	43	**13**	26	**8**	238	**71**
E00042052	136	204	**0.67**	184	**123**	126	**84**	58	**39**	56	**37**	273	**182**
E00042053	27	114	**0.24**	115	**27**	82	**19**	33	**8**	46	**11**	263	**62**
E00042054	29	145	**0.20**	138	**28**	80	**16**	58	**12**	40	**8**	251	**50**
E00042056	49	122	**0.40**	113	**45**	87	**35**	26	**10**	56	**22**	180	**72**
E00042057	75	120	**0.63**	122	**76**	97	**61**	25	**16**	61	**38**	332	**208**
E00042058	48	48	**1.00**	48	**48**	34	**34**	14	**14**	13	**13**	111	**111**
E00042691	50	77	**0.65**	85	**55**	76	**49**	9	**6**	33	**21**	172	**112**
E00042693	32	117	**0.27**	145	**40**	122	**33**	23	**6**	52	**14**	284	**78**
E00042695	77	77	**1.00**	133	**133**	130	**130**	3	**3**	84	**84**	105	**105**
E00042697	95	155	**0.61**	157	**96**	131	**80**	26	**16**	75	**46**	262	**161**
E00175554	187	193	**0.97**	181	**175**	135	**131**	46	**45**	56	**54**	387	**375**
E00175586	1	125	**0.01**	119	**1**	95	**1**	24	**0**	62	**0**	274	**2**

E00175597	76	165	**0.46**	147	**68**	101	**47**	46	**21**	36	**17**	385	**177**
Subtotal 4				1915	**992**	1467	**778**	448	**213**	729	**387**	3752	**1854**
Service Area 5													
E00042043	65	144	**0.45**	143	**65**	62	**28**	81	**37**	37	**17**	303	**137**
E00042048	90	137	**0.66**	146	**96**	76	**50**	70	**46**	58	**38**	297	**195**
E00042051	124	129	**0.96**	128	**123**	71	**68**	57	**55**	34	**33**	278	**267**
E00042054	123	145	**0.85**	138	**117**	80	**68**	58	**49**	40	**34**	251	**213**
E00042324	31	167	**0.19**	158	**29**	98	**18**	60	**11**	52	**10**	281	**52**
E00042338	46	159	**0.29**	160	**46**	109	**32**	51	**15**	64	**19**	330	**95**
E00042347	35	152	**0.23**	151	**35**	104	**24**	47	**11**	42	**10**	270	**62**
E00042685	57	57	**1.00**	54	**54**	41	**41**	13	**13**	20	**20**	100	**100**
E00042686	122	122	**1.00**	121	**121**	73	**73**	48	**48**	43	**43**	243	**243**
E00042687	116	116	**1.00**	122	**122**	75	**75**	47	**47**	40	**40**	266	**266**
E00042688	69	114	**0.61**	114	**69**	65	**39**	49	**30**	24	**15**	222	**134**
E00042689	140	140	**1.00**	134	**134**	89	**89**	45	**45**	40	**40**	301	**301**
E00042690	150	150	**1.00**	129	**129**	95	**95**	34	**34**	45	**45**	257	**257**
E00042691	27	77	**0.35**	85	**30**	76	**27**	9	**3**	33	**12**	172	**60**
E00042694	35	89	**0.39**	85	**33**	72	**28**	13	**5**	43	**17**	182	**72**
E00042702	83	117	**0.71**	119	**84**	79	**56**	40	**28**	23	**16**	246	**175**
E00042703	120	120	**1.00**	120	**120**	67	**67**	53	**53**	31	**31**	219	**219**
E00042704	111	121	**0.92**	125	**115**	64	**59**	61	**56**	34	**31**	285	**261**
E00042705	123	123	**1.00**	121	**121**	65	**65**	56	**56**	32	**32**	228	**228**
Subtotal 5				2353	**1643**	1461	**1002**	892	**642**	735	**501**	4731	**3338**
Service Area 6													
E00042610	26	133	**0.20**	131	**26**	89	**17**	42	**8**	53	**10**	239	**47**
E00042611	172	172	**1.00**	167	**167**	84	**84**	83	**83**	41	**41**	303	**303**
E00042612	131	133	**0.98**	123	**121**	104	**102**	19	**19**	57	**56**	141	**139**
E00042625	4	129	**0.03**	123	**4**	76	**2**	47	**1**	42	**1**	244	**8**
E00042627	9	116	**0.08**	116	**9**	83	**6**	33	**3**	55	**4**	199	**15**
E00042628	16	130	**0.12**	132	**16**	97	**12**	35	**4**	86	**11**	300	**37**
E00042634	57	123	**0.46**	121	**56**	78	**36**	43	**20**	41	**19**	278	**129**
E00042635	1	119	**0.01**	111	**1**	72	**1**	39	**0**	23	**0**	196	**2**
E00042636	129	129	**1.00**	143	**143**	86	**86**	57	**57**	41	**41**	233	**233**
E00042637	161	216	**0.75**	240	**179**	128	**95**	112	**83**	76	**57**	458	**341**

E00042638	134	134	**1.00**	129	**129**	86	**86**	43	**43**	21	**21**	230	**230**
Subtotal 6				1536	**851**	983	**529**	553	**322**	536	**261**	2821	**1483**
Service Area 7													
E00042614	41	140	**0.29**	130	**38**	87	**25**	43	**13**	47	**14**	237	**69**
E00042615	92	132	**0.70**	127	**89**	71	**49**	56	**39**	42	**29**	244	**170**
E00042617	17	131	**0.13**	132	**17**	63	**8**	69	**9**	41	**5**	277	**36**
E00042618	2	84	**0.02**	118	**3**	70	**2**	48	**1**	44	**1**	176	**4**
E00042619	120	120	**1.00**	118	**118**	62	**62**	56	**56**	58	**58**	220	**220**
E00042620	129	129	**1.00**	120	**120**	74	**74**	46	**46**	37	**37**	221	**221**
E00042621	119	119	**1.00**	117	**117**	90	**90**	27	**27**	37	**37**	218	**218**
E00042622	1	126	**0.01**	130	**1**	71	**1**	59	**0**	60	**0**	237	**2**
E00042623	45	121	**0.37**	121	**45**	91	**34**	30	**11**	36	**13**	264	**98**
E00042624	136	137	**0.99**	137	**136**	81	**80**	56	**56**	46	**46**	293	**291**
E00042627	71	116	**0.61**	116	**71**	83	**51**	33	**20**	55	**34**	199	**122**
E00042628	92	130	**0.71**	132	**93**	97	**69**	35	**25**	86	**61**	300	**212**
E00042629	144	144	**1.00**	142	**142**	113	**113**	29	**29**	64	**64**	223	**223**
E00042630	74	74	**1.00**	79	**79**	63	**63**	16	**16**	22	**22**	130	**130**
E00042631	125	125	**1.00**	119	**119**	85	**85**	34	**34**	21	**21**	177	**177**
E00042632	130	130	**1.00**	129	**129**	97	**97**	32	**32**	48	**48**	215	**215**
E00042635	77	119	**0.65**	111	**72**	72	**47**	39	**25**	23	**15**	196	**127**
Subtotal 7				2078	**1389**	1370	**950**	708	**439**	767	**505**	3827	**2535**
Service Area 8													
E00042467	1	125	**0.01**	165	**1**	47	**0**	118	**1**	10	**0**	335	**3**
E00042642	182	183	**0.99**	174	**173**	90	**90**	84	**84**	24	**24**	389	**387**
E00042643	78	153	**0.51**	151	**77**	76	**39**	75	**38**	28	**14**	413	**211**
E00042644	124	125	**0.99**	120	**119**	48	**48**	72	**71**	13	**13**	320	**317**
E00042645	185	185	**1.00**	172	**172**	73	**73**	99	**99**	8	**8**	435	**435**
E00042646	108	108	**1.00**	122	**122**	99	**99**	23	**23**	25	**25**	230	**230**
E00042647	14	97	**0.14**	95	**14**	49	**7**	46	**7**	15	**2**	203	**29**
E00042648	25	86	**0.29**	160	**47**	88	**26**	72	**21**	62	**18**	243	**71**
E00042649	13	125	**0.10**	115	**12**	51	**5**	64	**7**	10	**1**	284	**30**
E00042650	114	114	**1.00**	148	**148**	60	**60**	88	**88**	27	**27**	329	**329**
E00042651	25	129	**0.19**	125	**24**	52	**10**	73	**14**	13	**3**	316	**61**
E00042653	166	166	**1.00**	164	**164**	61	**61**	103	**103**	2	**2**	465	**465**

E00042655	101	101	**1.00**	95	**95**	45	**45**	50	**50**	6	**6**	241	**241**
E00042661	90	90	**1.00**	90	**90**	74	**74**	16	**16**	10	**10**	100	**100**
E00042663	94	94	**1.00**	92	**92**	46	**46**	46	**46**	13	**13**	219	**219**
E00042665	128	128	**1.00**	129	**129**	115	**115**	14	**14**	30	**30**	122	**122**
E00042667	33	79	**0.42**	80	**33**	31	**13**	49	**20**	6	**3**	192	**80**
E00042669	110	110	**1.00**	49	**49**	35	**35**	14	**14**	9	**9**	252	**252**
E00042670	152	152	**1.00**	146	**146**	111	**111**	35	**35**	40	**40**	329	**329**
E00042671	89	89	**1.00**	88	**88**	63	**63**	25	**25**	16	**16**	110	**110**
E00042672	95	95	**1.00**	90	**90**	71	**71**	19	**19**	13	**13**	1148	**1148**
E00042673	177	177	**1.00**	173	**173**	117	**117**	56	**56**	25	**25**	315	**315**
E00042674	169	169	**1.00**	168	**168**	128	**128**	40	**40**	52	**52**	195	**195**
E00042677	148	148	**1.00**	158	**158**	115	**115**	43	**43**	29	**29**	215	**215**
E00175555	111	111	**1.00**	112	**112**	55	**55**	57	**57**	4	**4**	413	**413**
E00175556	49	50	**0.98**	75	**74**	51	**50**	24	**24**	19	**19**	105	**103**
E00175578	50	60	**0.83**	110	**92**	81	**68**	29	**24**	9	**8**	882	**735**
E00175583	114	134	**0.85**	104	**88**	69	**59**	35	**30**	23	**20**	216	**184**
E00175588	106	106	**1.00**	105	**105**	86	**86**	19	**19**	33	**33**	134	**134**
E00175594	81	81	**1.00**	84	**84**	41	**41**	43	**43**	3	**3**	279	**279**
Subtotal 8				3659	**2939**	2128	**1808**	1531	**1130**	577	**468**	9429	**7741**
Service Area 9													
E00042439	224	224	**1.00**	197	**197**	86	**86**	111	**111**	9	**9**	589	**589**
E00042440	92	124	**0.74**	126	**93**	46	**34**	80	**59**	24	**18**	331	**246**
E00042441	108	154	**0.70**	176	**123**	75	**53**	101	**71**	18	**13**	411	**288**
E00042442	160	160	**1.00**	156	**156**	46	**46**	110	**110**	11	**11**	513	**513**
E00042443	198	217	**0.91**	183	**167**	64	**58**	119	**109**	8	**7**	416	**380**
E00042445	1	116	**0.01**	107	**1**	43	**0**	64	**1**	54	**0**	166	**1**
E00042447	2	136	**0.01**	133	**2**	53	**1**	80	**1**	6	**0**	379	**6**
E00042448	108	145	**0.74**	142	**106**	33	**25**	109	**81**	9	**7**	533	**397**
E00042451	164	164	**1.00**	165	**165**	74	**74**	91	**91**	15	**15**	364	**364**
E00042453	131	135	**0.97**	128	**124**	71	**69**	57	**55**	26	**25**	260	**252**
E00042454	43	133	**0.32**	125	**40**	40	**13**	85	**27**	8	**3**	332	**107**
E00042455	144	144	**1.00**	131	**131**	44	**44**	87	**87**	43	**43**	387	**387**
E00042456	41	109	**0.38**	109	**41**	44	**17**	65	**24**	34	**13**	261	**98**
E00042457	142	142	**1.00**	145	**145**	51	**51**	94	**94**	4	**4**	612	**612**

E00042458	154	154	**1.00**	167	**167**	63	**63**	104	**104**	18	**18**	417	**417**
E00042459	129	138	**0.93**	131	**122**	42	**39**	89	**83**	15	**14**	460	**430**
E00042460	106	129	**0.82**	123	**101**	42	**35**	81	**67**	12	**10**	402	**330**
E00042461	140	140	**1.00**	126	**126**	34	**34**	92	**92**	26	**26**	358	**358**
E00042462	148	148	**1.00**	144	**144**	54	**54**	90	**90**	25	**25**	423	**423**
E00042463	158	158	**1.00**	149	**149**	55	**55**	94	**94**	17	**17**	373	**373**
E00042464	120	143	**0.84**	161	**135**	56	**47**	105	**88**	31	**26**	286	**240**
E00042465	130	138	**0.94**	121	**114**	50	**47**	71	**67**	1	**1**	435	**410**
E00042466	134	134	**1.00**	119	**119**	45	**45**	74	**74**	91	**91**	210	**210**
E00042467	44	125	**0.35**	165	**58**	47	**17**	118	**42**	10	**4**	335	**118**
E00042468	182	204	**0.89**	227	**203**	93	**83**	134	**120**	39	**35**	409	**365**
E00042469	158	158	**1.00**	132	**132**	81	**81**	51	**51**	38	**38**	188	**188**
E00042471	74	170	**0.44**	135	**59**	54	**24**	81	**35**	33	**14**	293	**128**
E00042681	9	110	**0.08**	139	**11**	54	**4**	85	**7**	18	**1**	347	**28**
E00175594	7	81	**0.09**	84	**7**	41	**4**	43	**4**	3	**0**	279	**24**
Subtotal 9				4146	**3140**	1581	**1201**	2565	**1939**	646	**488**	10769	**8282**
Service Area 10													
E00042439	224	224	**1.00**	197	**197**	86	**86**	111	**111**	9	**9**	589	**589**
E00042440	70	124	**0.56**	126	**71**	46	**26**	80	**45**	24	**14**	331	**187**
E00042441	108	154	**0.70**	176	**123**	75	**53**	101	**71**	18	**13**	411	**288**
E00042442	159	160	**0.99**	156	**155**	46	**46**	110	**109**	11	**11**	513	**510**
E00042443	197	217	**0.91**	183	**166**	64	**58**	119	**108**	8	**7**	416	**378**
E00042444	20	154	**0.13**	155	**20**	54	**7**	101	**13**	10	**1**	422	**55**
E00042445	46	116	**0.40**	107	**42**	43	**17**	64	**25**	54	**21**	166	**66**
E00042447	102	136	**0.75**	133	**100**	53	**40**	80	**60**	6	**5**	379	**284**
E00042448	145	145	**1.00**	142	**142**	33	**33**	109	**109**	9	**9**	533	**533**
E00042450	5	185	**0.03**	183	**5**	50	**1**	133	**4**	7	**0**	602	**16**
E00042451	164	164	**1.00**	165	**165**	74	**74**	91	**91**	15	**15**	364	**364**
E00042452	3	167	**0.02**	157	**3**	53	**1**	104	**2**	9	**0**	504	**9**
E00042453	135	135	**1.00**	128	**128**	71	**71**	57	**57**	26	**26**	260	**260**
E00042454	4	133	**0.03**	125	**4**	40	**1**	85	**3**	8	**0**	332	**10**
E00042455	144	144	**1.00**	131	**131**	44	**44**	87	**87**	43	**43**	387	**387**
E00042456	43	109	**0.39**	109	**43**	44	**17**	65	**26**	34	**13**	261	**103**
E00042457	138	142	**0.97**	145	**141**	51	**50**	94	**91**	4	**4**	612	**595**

E00042458	154	154	**1.00**	167	**167**	63	**63**	104	**104**	18	**18**	417	**417**
E00042459	101	138	**0.73**	131	**96**	42	**31**	89	**65**	15	**11**	460	**337**
E00042460	103	129	**0.80**	123	**98**	42	**34**	81	**65**	12	**10**	402	**321**
E00042461	140	140	**1.00**	126	**126**	34	**34**	92	**92**	26	**26**	358	**358**
E00042462	148	148	**1.00**	144	**144**	54	**54**	90	**90**	25	**25**	423	**423**
E00042463	158	158	**1.00**	149	**149**	55	**55**	94	**94**	17	**17**	373	**373**
E00042464	118	143	**0.83**	161	**133**	56	**46**	105	**87**	31	**26**	286	**236**
E00042465	42	138	**0.30**	121	**37**	50	**15**	71	**22**	1	**0**	435	**132**
E00042466	134	134	**1.00**	119	**119**	45	**45**	74	**74**	91	**91**	210	**210**
E00042467	37	125	**0.30**	165	**49**	47	**14**	118	**35**	10	**3**	335	**99**
E00042468	186	204	**0.91**	227	**207**	93	**85**	134	**122**	39	**36**	409	**373**
E00042469	158	158	**1.00**	132	**132**	81	**81**	51	**51**	38	**38**	188	**188**
E00042470	3	160	**0.02**	133	**2**	33	**1**	100	**2**	33	**1**	338	**6**
E00042471	163	170	**0.96**	135	**129**	54	**52**	81	**78**	33	**32**	293	**281**
E00042472	1	136	**0.01**	111	**1**	58	**0**	53	**0**	50	**0**	139	**1**
E00042474	3	112	**0.03**	105	**3**	41	**1**	64	**2**	38	**1**	199	**5**
Subtotal 10				4767	**3229**	1775	**1235**	2992	**1994**	772	**525**	12347	**8394**
Service Area 11													
E00042439	45	224	**0.20**	197	**40**	86	**17**	111	**22**	9	**2**	589	**118**
E00042444	154	154	**1.00**	155	**155**	54	**54**	101	**101**	10	**10**	422	**422**
E00042445	55	116	**0.47**	107	**51**	43	**20**	64	**30**	54	**26**	166	**79**
E00042446	127	127	**1.00**	122	**122**	44	**44**	78	**78**	11	**11**	341	**341**
E00042447	136	136	**1.00**	133	**133**	53	**53**	80	**80**	6	**6**	379	**379**
E00042448	145	145	**1.00**	142	**142**	33	**33**	109	**109**	9	**9**	533	**533**
E00042449	115	115	**1.00**	106	**106**	24	**24**	82	**82**	16	**16**	305	**305**
E00042450	185	185	**1.00**	183	**183**	50	**50**	133	**133**	7	**7**	602	**602**
E00042451	148	164	**0.90**	165	**149**	74	**67**	91	**82**	15	**14**	364	**328**
E00042452	71	167	**0.43**	157	**67**	53	**23**	104	**44**	9	**4**	504	**214**
E00042453	128	135	**0.95**	128	**121**	71	**67**	57	**54**	26	**25**	260	**247**
E00042456	1	109	**0.01**	109	**1**	44	**0**	65	**1**	34	**0**	261	**2**
E00042458	77	154	**0.50**	167	**84**	63	**32**	104	**52**	18	**9**	417	**209**
E00042470	137	160	**0.86**	133	**114**	33	**28**	100	**86**	33	**28**	338	**289**
E00042471	170	170	**1.00**	135	**135**	54	**54**	81	**81**	33	**33**	293	**293**
E00042472	49	136	**0.36**	111	**40**	58	**21**	53	**19**	50	**18**	139	**50**

E00042473	112	112	**1.00**	116	**116**	31	**31**	85	**85**	34	**34**	315	**315**
E00042474	20	112	**0.18**	105	**19**	41	**7**	64	**11**	38	**7**	199	**36**
E00042475	104	104	**1.00**	101	**101**	27	**27**	74	**74**	3	**3**	335	**335**
E00042476	147	147	**1.00**	145	**145**	46	**46**	99	**99**	8	**8**	504	**504**
E00042477	146	146	**1.00**	147	**147**	47	**47**	100	**100**	10	**10**	450	**450**
E00042708	104	124	**0.84**	116	**97**	29	**24**	87	**73**	24	**20**	268	**225**
E00042709	129	134	**0.96**	132	**127**	58	**56**	74	**71**	44	**42**	288	**277**
E00042718	1	140	**0.01**	130	**1**	48	**0**	82	**1**	29	**0**	231	**2**
E00042721	58	134	**0.43**	130	**56**	48	**21**	82	**35**	69	**30**	307	**133**
E00042726	138	158	**0.87**	146	**128**	33	**29**	113	**99**	24	**21**	300	**262**
E00042727	143	143	**1.00**	139	**139**	37	**37**	102	**102**	17	**17**	337	**337**
E00042730	1	152	**0.01**	145	**1**	76	**1**	69	**0**	79	**1**	259	**2**
Subtotal 11				3802	**2718**	1358	**913**	2444	**1805**	719	**410**	9706	**7289**
Service Area 12													
E00042361	30	118	**0.25**	118	**30**	62	**16**	56	**14**	38	**10**	211	**54**
E00042364	23	128	**0.18**	132	**24**	72	**13**	60	**11**	66	**12**	200	**36**
E00042370	179	186	**0.96**	155	**149**	115	**111**	40	**38**	101	**97**	166	**160**
E00042371	153	153	**1.00**	149	**149**	55	**55**	94	**94**	40	**40**	266	**266**
E00042372	12	131	**0.09**	125	**11**	88	**8**	37	**3**	42	**4**	217	**20**
E00042373	53	124	**0.43**	126	**54**	35	**15**	91	**39**	43	**18**	317	**135**
E00042374	70	129	**0.54**	124	**67**	27	**15**	97	**53**	30	**16**	280	**152**
E00042375	115	115	**1.00**	137	**137**	68	**68**	69	**69**	46	**46**	231	**231**
E00042378	124	141	**0.88**	134	**118**	39	**34**	95	**84**	41	**36**	312	**274**
E00042379	181	181	**1.00**	170	**170**	52	**52**	118	**118**	29	**29**	323	**323**
E00042381	1	122	**0.01**	121	**1**	41	**0**	80	**1**	33	**0**	246	**2**
E00042383	35	141	**0.25**	138	**34**	44	**11**	94	**23**	39	**10**	450	**112**
E00042395	18	127	**0.14**	104	**15**	69	**10**	35	**5**	37	**5**	163	**23**
E00042396	48	172	**0.28**	131	**37**	88	**25**	43	**12**	40	**11**	163	**45**
E00042397	101	220	**0.46**	216	**99**	65	**30**	151	**69**	53	**24**	387	**178**
E00042400	28	124	**0.23**	122	**28**	69	**16**	53	**12**	87	**20**	266	**60**
E00042706	30	141	**0.21**	141	**30**	42	**9**	99	**21**	55	**12**	318	**68**
E00042707	33	143	**0.23**	153	**35**	32	**7**	121	**28**	65	**15**	351	**81**
E00042711	63	125	**0.50**	118	**59**	28	**14**	90	**45**	24	**12**	212	**107**
E00042712	21	183	**0.11**	136	**16**	36	**4**	100	**11**	32	**4**	269	**31**

E00042735	136	136	**1.00**	113	**113**	27	**27**	86	**86**	25	**25**	225	**225**
E00042739	107	115	**0.93**	112	**104**	25	**23**	87	**81**	38	**35**	281	**261**
Subtotal 12				2975	**1480**	1179	**562**	1796	**918**	1004	**481**	5854	**2844**
Service Area 13													
E00042378	2	141	**0.01**	134	**2**	39	**1**	95	**1**	41	**1**	312	**4**
E00042706	58	141	**0.41**	141	**58**	42	**17**	99	**41**	55	**23**	318	**131**
E00042707	138	143	**0.97**	153	**148**	32	**31**	121	**117**	65	**63**	351	**339**
E00042708	42	124	**0.34**	116	**39**	29	**10**	87	**29**	24	**8**	268	**91**
E00042710	144	144	**1.00**	145	**145**	55	**55**	90	**90**	43	**43**	281	**281**
E00042712	183	183	**1.00**	136	**136**	36	**36**	100	**100**	32	**32**	269	**269**
E00042713	234	243	**0.96**	238	**229**	99	**95**	139	**134**	138	**133**	372	**358**
E00042717	143	250	**0.57**	233	**133**	85	**49**	148	**85**	43	**25**	501	**287**
E00042723	19	132	**0.14**	131	**19**	54	**8**	77	**11**	55	**8**	305	**44**
E00042725	143	158	**0.91**	148	**134**	49	**44**	99	**90**	83	**75**	305	**276**
E00042726	158	158	**1.00**	146	**146**	33	**33**	113	**113**	24	**24**	300	**300**
E00042727	93	143	**0.65**	139	**90**	37	**24**	102	**66**	17	**11**	337	**219**
E00042728	128	128	**1.00**	124	**124**	33	**33**	91	**91**	42	**42**	312	**312**
E00042729	116	116	**1.00**	116	**116**	27	**27**	89	**89**	35	**35**	279	**279**
E00042730	58	152	**0.38**	145	**55**	76	**29**	69	**26**	79	**30**	259	**99**
E00042731	42	131	**0.32**	130	**42**	36	**12**	94	**30**	42	**13**	294	**94**
E00042735	20	136	**0.15**	113	**17**	27	**4**	86	**13**	25	**4**	225	**33**
E00042739	38	115	**0.33**	112	**37**	25	**8**	87	**29**	38	**13**	281	**93**
Subtotal 13				2600	**1670**	814	**515**	1786	**1155**	881	**581**	5569	**3509**
Service Area 14													
E00042370	59	186	**0.32**	155	**49**	115	**36**	40	**13**	101	**32**	166	**53**
E00042378	17	141	**0.12**	134	**16**	39	**5**	95	**11**	41	**5**	312	**38**
E00042379	49	181	**0.27**	170	**46**	52	**14**	118	**32**	29	**8**	323	**87**
E00042381	1	122	**0.01**	121	**1**	41	**0**	80	**1**	33	**0**	246	**2**
E00042706	110	141	**0.78**	141	**110**	42	**33**	99	**77**	55	**43**	318	**248**
E00042707	143	143	**1.00**	153	**153**	32	**32**	121	**121**	65	**65**	351	**351**
E00042708	8	124	**0.06**	116	**7**	29	**2**	87	**6**	24	**2**	268	**17**
E00042710	144	144	**1.00**	145	**145**	55	**55**	90	**90**	43	**43**	281	**281**
E00042711	24	125	**0.19**	118	**23**	28	**5**	90	**17**	24	**5**	212	**41**
E00042712	183	183	**1.00**	136	**136**	36	**36**	100	**100**	32	**32**	269	**269**

E00042713	242	243	**1.00**	238	**237**	99	**99**	139	**138**	138	**137**	372	**370**
E00042714	12	124	**0.10**	124	**12**	43	**4**	81	**8**	52	**5**	214	**21**
E00042717	208	250	**0.83**	233	**194**	85	**71**	148	**123**	43	**36**	501	**417**
E00042718	9	140	**0.06**	130	**8**	48	**3**	82	**5**	29	**2**	231	**15**
E00042723	44	132	**0.33**	131	**44**	54	**18**	77	**26**	55	**18**	305	**102**
E00042725	158	158	**1.00**	148	**148**	49	**49**	99	**99**	83	**83**	305	**305**
E00042726	142	158	**0.90**	146	**131**	33	**30**	113	**102**	24	**22**	300	**270**
E00042727	46	143	**0.32**	139	**45**	37	**12**	102	**33**	17	**5**	337	**108**
E00042728	128	128	**1.00**	124	**124**	33	**33**	91	**91**	42	**42**	312	**312**
E00042729	116	116	**1.00**	116	**116**	27	**27**	89	**89**	35	**35**	279	**279**
E00042730	46	152	**0.30**	145	**44**	76	**23**	69	**21**	79	**24**	259	**78**
E00042731	21	131	**0.16**	130	**21**	36	**6**	94	**15**	42	**7**	294	**47**
E00042735	76	136	**0.56**	113	**63**	27	**15**	86	**48**	25	**14**	225	**126**
E00042739	95	115	**0.83**	112	**93**	25	**21**	87	**72**	38	**31**	281	**232**
Subtotal 14				3418	**1966**	1141	**628**	2277	**1337**	1149	**696**	6961	**4069**
Service Area 15													
E00042366	23	123	**0.19**	124	**23**	77	**14**	47	**9**	27	**5**	226	**42**
E00042370	186	186	**1.00**	155	**155**	115	**115**	40	**40**	101	**101**	166	**166**
E00042371	153	153	**1.00**	149	**149**	55	**55**	94	**94**	40	**40**	266	**266**
E00042372	127	131	**0.97**	125	**121**	88	**85**	37	**36**	42	**41**	217	**210**
E00042373	124	124	**1.00**	126	**126**	35	**35**	91	**91**	43	**43**	317	**317**
E00042374	129	129	**1.00**	124	**124**	27	**27**	97	**97**	30	**30**	280	**280**
E00042375	115	115	**1.00**	137	**137**	68	**68**	69	**69**	46	**46**	231	**231**
E00042378	141	141	**1.00**	134	**134**	39	**39**	95	**95**	41	**41**	312	**312**
E00042379	181	181	**1.00**	170	**170**	52	**52**	118	**118**	29	**29**	323	**323**
E00042381	122	122	**1.00**	121	**121**	41	**41**	80	**80**	33	**33**	246	**246**
E00042382	147	147	**1.00**	147	**147**	83	**83**	64	**64**	50	**50**	197	**197**
E00042383	31	141	**0.22**	138	**30**	44	**10**	94	**21**	39	**9**	450	**99**
E00042397	37	220	**0.17**	216	**36**	65	**11**	151	**25**	53	**9**	387	**65**
E00042400	1	124	**0.01**	122	**1**	69	**1**	53	**0**	87	**1**	266	**2**
E00042706	141	141	**1.00**	141	**141**	42	**42**	99	**99**	55	**55**	318	**318**
E00042707	141	143	**0.99**	153	**151**	32	**32**	121	**119**	65	**64**	351	**346**
E00042710	10	144	**0.07**	145	**10**	55	**4**	90	**6**	43	**3**	281	**20**
E00042711	124	125	**0.99**	118	**117**	28	**28**	90	**89**	24	**24**	212	**210**

E00042712	170	183	**0.93**	136	**126**	36	**33**	100	**93**	32	**30**	269	**250**
E00042713	132	243	**0.54**	238	**129**	99	**54**	139	**76**	138	**75**	372	**202**
E00042714	1	124	**0.01**	124	**1**	43	**0**	81	**1**	52	**0**	214	**2**
E00042717	148	250	**0.59**	233	**138**	85	**50**	148	**88**	43	**25**	501	**297**
E00042725	23	158	**0.15**	148	**22**	49	**7**	99	**14**	83	**12**	305	**44**
E00042735	136	136	**1.00**	113	**113**	27	**27**	86	**86**	25	**25**	225	**225**
E00042739	115	115	**1.00**	112	**112**	25	**25**	87	**87**	38	**38**	281	**281**
Subtotal 15				3649	**2535**	1379	**938**	2270	**1597**	1259	**828**	7213	**4951**
Service Area 16													
E00042068	117	117	**1.00**	120	**120**	61	**61**	59	**59**	35	**35**	285	**285**
E00042069	41	138	**0.30**	138	**41**	73	**22**	65	**19**	44	**13**	290	**86**
E00042071	51	122	**0.42**	122	**51**	62	**26**	60	**25**	35	**15**	240	**100**
E00042082	112	126	**0.89**	124	**110**	52	**46**	72	**64**	54	**48**	242	**215**
E00042083	5	122	**0.04**	125	**5**	52	**2**	73	**3**	29	**1**	284	**12**
E00042084	86	124	**0.69**	120	**83**	48	**33**	72	**50**	12	**8**	224	**155**
E00042140	92	127	**0.72**	125	**91**	72	**52**	53	**38**	36	**26**	258	**187**
E00042141	96	135	**0.71**	133	**95**	57	**41**	76	**54**	45	**32**	307	**218**
E00042145	2	116	**0.02**	118	**2**	61	**1**	57	**1**	34	**1**	240	**4**
E00042149	77	125	**0.62**	126	**78**	55	**34**	71	**44**	32	**20**	288	**177**
E00042150	10	119	**0.08**	120	**10**	43	**4**	77	**6**	15	**1**	278	**23**
E00042151	9	119	**0.08**	116	**9**	57	**4**	59	**4**	29	**2**	249	**19**
Subtotal 16				1487	**694**	693	**326**	794	**368**	400	**202**	3185	**1483**
Service Area 17													
E00042068	117	117	**1.00**	120	**120**	61	**61**	59	**59**	35	**35**	285	**285**
E00042069	41	138	**0.30**	138	**41**	73	**22**	65	**19**	44	**13**	290	**86**
E00042071	51	122	**0.42**	122	**51**	62	**26**	60	**25**	35	**15**	240	**100**
E00042082	112	126	**0.89**	124	**110**	52	**46**	72	**64**	54	**48**	242	**215**
E00042083	5	122	**0.04**	125	**5**	52	**2**	73	**3**	29	**1**	284	**12**
E00042084	86	124	**0.69**	120	**83**	48	**33**	72	**50**	12	**8**	224	**155**
E00042140	92	127	**0.72**	125	**91**	72	**52**	53	**38**	36	**26**	258	**187**
E00042141	96	135	**0.71**	133	**95**	57	**41**	76	**54**	45	**32**	307	**218**
E00042145	2	116	**0.02**	118	**2**	61	**1**	57	**1**	34	**1**	240	**4**
E00042149	77	125	**0.62**	126	**78**	55	**34**	71	**44**	32	**20**	288	**177**
E00042150	10	119	**0.08**	120	**10**	43	**4**	77	**6**	15	**1**	278	**23**

E00042151	9	119	**0.08**	116	**9**	57	**4**	59	**4**	29	**2**	249	**19**
Subtotal 17				1487	**694**	693	**326**	794	**368**	400	**202**	3185	**1483**
Service Area 18													
E00042072	119	119	**1.00**	117	**117**	86	**86**	31	**31**	39	**39**	239	**239**
E00042073	44	121	**0.36**	114	**41**	73	**27**	41	**15**	41	**15**	287	**104**
E00042074	2	113	**0.02**	110	**2**	82	**1**	28	**0**	30	**1**	220	**4**
E00042295	147	147	**1.00**	134	**134**	107	**107**	27	**27**	29	**29**	340	**340**
E00042296	109	111	**0.98**	146	**143**	115	**113**	31	**30**	41	**40**	215	**211**
E00042299	138	138	**1.00**	137	**137**	97	**97**	40	**40**	30	**30**	310	**310**
E00042300	109	109	**1.00**	121	**121**	90	**90**	31	**31**	31	**31**	246	**246**
E00042301	118	122	**0.97**	127	**123**	93	**90**	34	**33**	45	**44**	289	**280**
E00042302	49	126	**0.39**	121	**47**	79	**31**	42	**16**	35	**14**	277	**108**
E00042303	198	198	**1.00**	137	**137**	99	**99**	38	**38**	43	**43**	182	**182**
E00042304	87	141	**0.62**	143	**88**	103	**64**	40	**25**	40	**25**	257	**159**
E00042306	136	136	**1.00**	134	**134**	88	**88**	46	**46**	37	**37**	209	**209**
E00042307	26	95	**0.27**	95	**26**	70	**19**	25	**7**	38	**10**	227	**62**
E00042308	118	123	**0.96**	117	**112**	94	**90**	23	**22**	42	**40**	294	**282**
E00042320	28	130	**0.22**	116	**25**	60	**13**	56	**12**	39	**8**	224	**48**
E00042480	10	121	**0.08**	124	**10**	59	**5**	65	**5**	41	**3**	280	**23**
E00042485	15	127	**0.12**	126	**15**	77	**9**	49	**6**	48	**6**	254	**30**
E00042510	129	129	**1.00**	123	**123**	94	**94**	29	**29**	38	**38**	256	**256**
Subtotal 18				2242	**1536**	1566	**1122**	676	**414**	687	**453**	4606	**3093**
Service Area 19													
E00042072	61	119	**0.51**	117	**60**	86	**44**	31	**16**	39	**20**	239	**123**
E00042073	12	121	**0.10**	114	**11**	73	**7**	41	**4**	41	**4**	287	**28**
E00042295	52	147	**0.35**	134	**47**	107	**38**	27	**10**	29	**10**	340	**120**
E00042296	1	111	**0.01**	146	**1**	115	**1**	31	**0**	41	**0**	215	**2**
E00042299	96	138	**0.70**	137	**95**	97	**67**	40	**28**	30	**21**	310	**216**
E00042300	43	109	**0.39**	121	**48**	90	**36**	31	**12**	31	**12**	246	**97**
E00042301	58	122	**0.48**	127	**60**	93	**44**	34	**16**	45	**21**	289	**137**
E00042302	27	126	**0.21**	121	**26**	79	**17**	42	**9**	35	**8**	277	**59**
E00042303	198	198	**1.00**	137	**137**	99	**99**	38	**38**	43	**43**	182	**182**
E00042304	100	141	**0.71**	143	**101**	103	**73**	40	**28**	40	**28**	257	**182**
E00042305	62	151	**0.41**	145	**60**	112	**46**	33	**14**	45	**18**	282	**116**

E00042306	136	136	**1.00**	134	**134**	88	**88**	46	**46**	37	**37**	209	**209**
E00042307	95	95	**1.00**	95	**95**	70	**70**	25	**25**	38	**38**	227	**227**
E00042308	123	123	**1.00**	117	**117**	94	**94**	23	**23**	42	**42**	294	**294**
E00042480	121	121	**1.00**	117	**117**	94	**94**	23	**23**	42	**42**	294	**294**
E00042483	56	115	**0.49**	115	**56**	42	**20**	73	**36**	37	**18**	273	**133**
E00042484	109	114	**0.96**	114	**109**	52	**50**	62	**59**	29	**28**	242	**231**
E00042485	127	127	**1.00**	126	**126**	77	**77**	49	**49**	48	**48**	254	**254**
E00042486	2	107	**0.02**	111	**2**	85	**2**	26	**0**	41	**1**	181	**3**
E00042487	7	126	**0.06**	127	**7**	69	**4**	58	**3**	51	**3**	300	**17**
E00042488	7	117	**0.06**	115	**7**	71	**4**	44	**3**	39	**2**	215	**13**
E00042489	91	115	**0.79**	112	**89**	46	**36**	66	**52**	36	**28**	259	**205**
E00042493	30	118	**0.25**	116	**29**	69	**18**	47	**12**	40	**10**	209	**53**
E00042510	129	129	**1.00**	123	**123**	94	**94**	29	**29**	38	**38**	256	**256**
E00042511	67	126	**0.53**	122	**65**	62	**33**	60	**32**	46	**24**	248	**132**
E00042512	118	118	**1.00**	118	**118**	44	**44**	74	**74**	42	**42**	268	**268**
Subtotal 19				3204	**1841**	2111	**1200**	1093	**641**	1025	**588**	6653	**3852**
Service Area 20													
E00042178	22	132	**0.17**	135	**23**	45	**8**	90	**15**	49	**8**	288	**48**
E00042360	7	200	**0.04**	141	**5**	86	**3**	55	**2**	48	**2**	267	**9**
E00042361	3	118	**0.03**	118	**3**	62	**2**	56	**1**	38	**1**	211	**5**
E00042363	120	120	**1.00**	117	**117**	53	**53**	64	**64**	49	**49**	245	**245**
E00042375	1	115	**0.01**	137	**1**	68	**1**	69	**1**	46	**0**	231	**2**
E00042385	14	130	**0.11**	130	**14**	44	**5**	86	**9**	38	**4**	311	**33**
E00042386	102	123	**0.83**	119	**99**	43	**36**	76	**63**	30	**25**	283	**235**
E00042387	90	112	**0.80**	108	**87**	43	**35**	65	**52**	37	**30**	195	**157**
E00042388	225	225	**1.00**	215	**215**	97	**97**	118	**118**	91	**91**	358	**358**
E00042389	96	96	**1.00**	96	**96**	30	**30**	66	**66**	31	**31**	243	**243**
E00042390	132	132	**1.00**	97	**97**	70	**70**	27	**27**	37	**37**	127	**127**
E00042391	103	103	**1.00**	101	**101**	43	**43**	58	**58**	35	**35**	244	**244**
E00042392	140	145	**0.97**	115	**111**	77	**74**	38	**37**	25	**24**	171	**165**
E00042393	82	123	**0.67**	120	**80**	85	**57**	35	**23**	29	**19**	265	**177**
E00042394	121	122	**0.99**	118	**117**	58	**58**	60	**60**	42	**42**	288	**286**
E00042395	127	127	**1.00**	104	**104**	69	**69**	35	**35**	37	**37**	163	**163**
E00042396	172	172	**1.00**	131	**131**	88	**88**	43	**43**	40	**40**	163	**163**

E00042397	220	220	**1.00**	216	**216**	65	**65**	151	**151**	53	**53**	387	**387**
E00042399	4	134	**0.03**	129	**4**	63	**2**	66	**2**	43	**1**	270	**8**
E00042400	52	124	**0.42**	122	**51**	69	**29**	53	**22**	87	**36**	266	**112**
Subtotal 20				2569	**1671**	1258	**822**	1311	**849**	885	**566**	4976	**3167**
Service Area 21													
E00042169	112	112	**1.00**	118	**118**	48	**48**	70	**70**	66	**66**	225	**225**
E00042170	120	120	**1.00**	121	**121**	48	**48**	73	**73**	49	**49**	265	**265**
E00042173	114	114	**1.00**	117	**117**	41	**41**	76	**76**	54	**54**	260	**260**
E00042174	132	132	**1.00**	122	**122**	50	**50**	72	**72**	92	**92**	225	**225**
E00042175	22	122	**0.18**	124	**22**	51	**9**	73	**13**	58	**10**	265	**48**
E00042176	128	128	**1.00**	129	**129**	49	**49**	80	**80**	55	**55**	285	**285**
E00042177	88	124	**0.71**	121	**86**	56	**40**	65	**46**	74	**53**	179	**127**
E00042178	95	132	**0.72**	135	**97**	45	**32**	90	**65**	49	**35**	288	**207**
E00042387	5	219	**0.02**	108	**2**	43	**1**	65	**1**	37	**1**	195	**4**
E00175566	83	116	**0.72**	116	**83**	59	**42**	57	**41**	59	**42**	182	**130**
E00175573	4	126	**0.03**	118	**4**	28	**1**	90	**3**	40	**1**	290	**9**
Subtotal 21				1329	**902**	518	**361**	811	**540**	633	**459**	2659	**1786**
Service Area 22													
E00042282	5	123	**0.04**	106	**4**	69	**3**	37	**2**	40	**2**	270	**11**
E00042576	32	128	**0.25**	128	**32**	89	**22**	39	**10**	39	**10**	337	**84**
E00042578	7	137	**0.05**	116	**6**	82	**4**	34	**2**	45	**2**	268	**14**
E00042581	128	128	**1.00**	126	**126**	107	**107**	19	**19**	56	**56**	205	**205**
E00042582	129	129	**1.00**	118	**118**	94	**94**	24	**24**	37	**37**	226	**226**
E00042585	28	96	**0.29**	96	**28**	80	**23**	16	**5**	36	**11**	209	**61**
E00042587	130	130	**1.00**	127	**127**	100	**100**	27	**27**	38	**38**	257	**257**
E00042588	109	145	**0.75**	130	**98**	94	**71**	36	**27**	45	**34**	325	**244**
E00042606	153	153	**1.00**	147	**147**	91	**91**	56	**56**	39	**39**	367	**367**
E00042607	149	149	**1.00**	141	**141**	91	**91**	50	**50**	47	**47**	336	**336**
E00042608	143	143	**1.00**	144	**144**	100	**100**	44	**44**	66	**66**	377	**377**
E00042873	68	147	**0.46**	137	**63**	75	**35**	62	**29**	26	**12**	299	**138**
E00042874	170	170	**1.00**	166	**166**	91	**91**	75	**75**	34	**34**	523	**523**
E00042877	155	155	**1.00**	141	**141**	81	**81**	60	**60**	47	**47**	439	**439**
E00042899	153	153	**1.00**	147	**147**	79	**79**	68	**68**	42	**42**	451	**451**
E00042900	136	136	**1.00**	138	**138**	61	**61**	77	**77**	33	**33**	476	**476**

E00042901	119	119	**1.00**	110	**110**	56	**56**	54	**54**	24	**24**	336	**336**
E00042903	52	152	**0.34**	137	**47**	87	**30**	50	**17**	48	**16**	326	**112**
E00175600	6	90	**0.07**	89	**1783**	61	**1139**	28	**2**	15	**1**	135	**9**
Subtotal 22				2444	**3566**	1588	**2277**	856	**646**	757	**550**	6162	**4666**
Service Area 23													
E00042272	100	149	**0.67**	157	**105**	104	**70**	53	**36**	95	**64**	514	**345**
E00042276	130	130	**1.00**	114	**114**	83	**83**	31	**31**	52	**52**	320	**320**
E00042277	121	121	**1.00**	119	**119**	87	**87**	32	**32**	28	**28**	385	**385**
E00042279	13	115	**0.11**	112	**13**	85	**10**	27	**3**	90	**10**	304	**34**
E00042281	28	141	**0.20**	133	**26**	79	**16**	54	**11**	57	**11**	296	**59**
E00042282	112	123	**0.91**	106	**97**	69	**63**	37	**34**	40	**36**	270	**246**
E00042284	162	162	**1.00**	144	**144**	118	**118**	26	**26**	59	**59**	430	**430**
E00042285	150	150	**1.00**	136	**136**	103	**103**	33	**33**	55	**55**	349	**349**
E00042287	123	123	**1.00**	110	**110**	91	**91**	19	**19**	32	**32**	266	**266**
E00042578	3	137	**0.02**	116	**3**	82	**2**	34	**1**	45	**1**	268	**6**
E00042588	40	145	**0.28**	130	**36**	94	**26**	36	**10**	45	**12**	325	**90**
E00042803	1	156	**0.01**	161	**1**	137	**1**	24	**0**	50	**0**	341	**2**
E00042805	44	151	**0.29**	135	**39**	126	**37**	9	**3**	34	**10**	188	**55**
E00042808	103	114	**0.90**	119	**108**	92	**83**	27	**24**	48	**43**	227	**205**
E00042811	125	126	**0.99**	124	**123**	110	**109**	14	**14**	32	**32**	359	**356**
E00042812	1	194	**0.01**	148	**1**	136	**1**	12	**0**	32	**0**	146	**1**
E00042823	28	138	**0.20**	139	**28**	118	**24**	21	**4**	36	**7**	249	**51**
E00042824	78	141	**0.55**	142	**79**	127	**70**	15	**8**	55	**30**	259	**143**
E00042827	24	153	**0.16**	136	**21**	110	**17**	26	**4**	50	**8**	352	**55**
E00042877	9	155	**0.06**	141	**8**	81	**5**	60	**3**	47	**3**	439	**25**
E00042899	67	153	**0.44**	147	**64**	79	**35**	68	**30**	42	**18**	451	**197**
E00175577	129	136	**0.95**	139	**132**	101	**96**	38	**36**	99	**94**	276	**262**
Subtotal 23				2908	**1507**	2212	**1145**	696	**362**	1123	**607**	7014	**3882**
Service Area 24													
E00042277	19	121	**0.16**	119	**19**	87	**14**	32	**5**	28	**4**	385	**60**
E00042284	10	162	**0.06**	144	**9**	118	**7**	26	**2**	59	**4**	430	**27**
E00042287	108	162	**0.67**	110	**73**	91	**61**	19	**13**	32	**21**	266	**177**
E00042586	3	156	**0.02**	159	**3**	126	**2**	33	**1**	61	**1**	377	**7**
E00042805	151	151	**1.00**	135	**135**	126	**126**	9	**9**	34	**34**	188	**188**

E00042806	121	121	**1.00**	118	**118**	86	**86**	32	**32**	38	**38**	255	**255**
E00042807	155	155	**1.00**	143	**143**	121	**121**	22	**22**	17	**17**	178	**178**
E00042810	110	126	**0.87**	117	**102**	100	**87**	17	**15**	36	**31**	280	**244**
E00042811	109	126	**0.87**	124	**107**	110	**95**	14	**12**	32	**28**	359	**311**
E00042812	193	194	**0.99**	148	**147**	136	**135**	12	**12**	32	**32**	146	**145**
E00042814	127	127	**1.00**	120	**120**	100	**100**	20	**20**	54	**54**	202	**202**
E00042816	128	137	**0.93**	54	**50**	41	**38**	13	**12**	13	**12**	115	**107**
E00042818	151	151	**1.00**	154	**154**	130	**130**	24	**24**	12	**12**	179	**179**
E00042819	151	151	**1.00**	138	**138**	104	**104**	34	**34**	2	**2**	169	**169**
E00042823	138	138	**1.00**	139	**139**	118	**118**	21	**21**	36	**36**	249	**249**
E00042824	141	141	**1.00**	142	**142**	127	**127**	15	**15**	55	**55**	259	**259**
E00042825	86	168	**0.51**	178	**91**	104	**53**	74	**38**	11	**6**	352	**180**
E00042827	153	153	**1.00**	136	**136**	110	**110**	26	**26**	50	**50**	352	**352**
E00042828	113	113	**1.00**	135	**135**	79	**79**	56	**56**	30	**30**	283	**283**
E00175577	72	136	**0.53**	139	**74**	101	**53**	38	**20**	99	**52**	276	**146**
Subtotal 24				2652	**2036**	2115	**1648**	537	**388**	731	**520**	5300	**3720**
Service Area 25													
E00042064	4	135	**0.03**	171	**5**	136	**4**	35	**1**	66	**2**	285	**8**
E00042262	174	183	**0.95**	174	**165**	123	**117**	51	**48**	64	**61**	470	**447**
E00042265	19	151	**0.13**	140	**18**	95	**12**	45	**6**	56	**7**	310	**39**
E00042266	155	183	**0.85**	173	**147**	122	**103**	51	**43**	78	**66**	434	**368**
E00042267	140	140	**1.00**	123	**123**	80	**80**	43	**43**	56	**56**	345	**345**
E00042270	37	149	**0.25**	137	**34**	91	**23**	46	**11**	52	**13**	348	**86**
E00042271	129	129	**1.00**	131	**131**	74	**74**	57	**57**	61	**61**	384	**384**
E00042272	149	149	**1.00**	157	**157**	104	**104**	53	**53**	95	**95**	514	**514**
E00042273	138	138	**1.00**	128	**128**	91	**91**	37	**37**	59	**59**	404	**404**
E00042275	129	129	**1.00**	128	**128**	83	**83**	45	**45**	65	**65**	403	**403**
E00042276	130	130	**1.00**	114	**114**	83	**83**	31	**31**	52	**52**	320	**320**
E00042277	79	121	**0.65**	119	**78**	87	**57**	32	**21**	28	**18**	385	**251**
E00042279	115	115	**1.00**	112	**112**	85	**85**	27	**27**	90	**90**	304	**304**
E00042280	45	201	**0.22**	177	**40**	135	**30**	42	**9**	62	**14**	432	**97**
E00042281	141	141	**1.00**	133	**133**	79	**79**	54	**54**	57	**57**	296	**296**
E00042282	123	123	**1.00**	106	**106**	69	**69**	37	**37**	40	**40**	270	**270**
E00042284	65	162	**0.40**	144	**58**	118	**47**	26	**10**	59	**24**	430	**173**

E00042285	68	150	**0.45**	136	**62**	103	**47**	33	**15**	55	**25**	349	**158**
E00042286	95	177	**0.54**	162	**87**	106	**57**	56	**30**	66	**35**	328	**176**
E00042356	12	121	**0.10**	122	**12**	70	**7**	52	**5**	45	**4**	369	**37**
E00042357	71	129	**0.55**	124	**68**	80	**44**	44	**24**	77	**42**	394	**217**
E00042578	32	137	**0.23**	116	**27**	82	**19**	34	**8**	45	**11**	268	**63**
E00042582	20	129	**0.16**	118	**18**	94	**15**	24	**4**	37	**6**	226	**35**
E00042587	46	130	**0.35**	127	**45**	100	**35**	27	**10**	38	**13**	257	**91**
E00042588	139	145	**0.96**	130	**125**	94	**90**	36	**35**	45	**43**	325	**312**
E00042608	81	143	**0.57**	144	**82**	100	**57**	44	**25**	66	**37**	377	**214**
E00042808	26	114	**0.23**	119	**27**	92	**21**	27	**6**	48	**11**	227	**52**
E00042823	8	138	**0.06**	139	**8**	118	**7**	21	**1**	36	**2**	249	**14**
E00042824	2	141	**0.01**	142	**2**	127	**2**	15	**0**	55	**1**	259	**4**
E00042873	86	147	**0.59**	137	**80**	75	**44**	62	**36**	26	**15**	299	**175**
E00042874	170	170	**1.00**	166	**166**	91	**91**	75	**75**	34	**34**	523	**523**
E00042875	165	165	**1.00**	125	**125**	79	**79**	46	**46**	39	**39**	321	**321**
E00042877	140	155	**0.90**	141	**127**	81	**73**	60	**54**	47	**42**	439	**397**
E00042878	144	144	**1.00**	129	**129**	74	**74**	55	**55**	88	**88**	399	**399**
E00042879	121	122	**0.99**	122	**121**	85	**84**	37	**37**	52	**52**	378	**375**
E00042896	18	129	**0.14**	111	**15**	43	**6**	68	**9**	31	**4**	277	**39**
E00042897	2	122	**0.02**	117	**2**	52	**1**	65	**1**	106	**2**	292	**5**
E00042898	127	140	**0.91**	126	**114**	71	**64**	55	**50**	42	**38**	315	**286**
E00042899	153	153	**1.00**	147	**147**	79	**79**	68	**68**	42	**42**	451	**451**
E00042900	27	136	**0.20**	138	**27**	61	**12**	77	**15**	33	**7**	476	**95**
E00042902	78	127	**0.61**	123	**76**	73	**45**	50	**31**	62	**38**	310	**190**
E00042903	152	152	**1.00**	137	**137**	87	**87**	50	**50**	48	**48**	326	**326**
Subtotal 25				5665	**3506**	3772	**2281**	1893	**1225**	2303	**1460**	14768	**9661**
Service Area 26													
E00042045	91	121	**0.75**	118	**89**	91	**68**	27	**20**	30	**23**	204	**153**
E00042046	130	153	**0.85**	161	**137**	118	**100**	43	**37**	50	**42**	411	**349**
E00042047	150	150	**1.00**	154	**154**	116	**116**	38	**38**	45	**45**	301	**301**
E00042056	74	122	**0.61**	113	**69**	87	**53**	26	**16**	56	**34**	180	**109**
E00042057	16	120	**0.13**	122	**16**	97	**13**	25	**3**	61	**8**	332	**44**
E00042059	137	137	**1.00**	135	**135**	101	**101**	34	**34**	52	**52**	272	**272**
E00042061	170	170	**1.00**	139	**139**	116	**116**	23	**23**	59	**59**	283	**283**

E00042062	178	178	**1.00**	178	**178**	137	**137**	41	**41**	73	**73**	428	**428**
E00042064	135	135	**1.00**	171	**171**	136	**136**	35	**35**	66	**66**	285	**285**
E00042065	166	166	**1.00**	143	**143**	117	**117**	26	**26**	29	**29**	269	**269**
E00042066	65	65	**1.00**	98	**98**	84	**84**	14	**14**	29	**29**	103	**103**
E00042262	60	183	**0.33**	174	**57**	123	**40**	51	**17**	64	**21**	470	**154**
E00042263	2	157	**0.01**	152	**2**	94	**1**	58	**1**	44	**1**	296	**4**
E00042264	16	128	**0.13**	132	**17**	85	**11**	47	**6**	51	**6**	237	**30**
E00042265	2	151	**0.01**	140	**2**	95	**1**	45	**1**	56	**1**	310	**4**
E00042269	168	181	**0.93**	158	**147**	123	**114**	35	**32**	63	**58**	342	**317**
E00042270	46	149	**0.31**	137	**42**	91	**28**	46	**14**	52	**16**	348	**107**
E00042274	111	134	**0.83**	125	**104**	90	**75**	35	**29**	45	**37**	246	**204**
E00042275	9	129	**0.07**	128	**9**	83	**6**	45	**3**	65	**5**	403	**28**
E00042278	142	142	**1.00**	115	**115**	104	**104**	11	**11**	42	**42**	214	**214**
E00042280	77	201	**0.38**	177	**68**	135	**52**	42	**16**	62	**24**	432	**165**
E00042281	59	141	**0.42**	133	**56**	79	**33**	54	**23**	57	**24**	296	**124**
E00042283	158	158	**1.00**	145	**145**	139	**139**	6	**6**	51	**51**	131	**131**
E00042286	166	177	**0.94**	162	**152**	106	**99**	56	**53**	66	**62**	328	**308**
E00175597	75	165	**0.45**	147	**67**	101	**46**	46	**21**	36	**16**	385	**175**
Subtotal 26				3557	**2309**	2648	**1791**	909	**519**	1304	**824**	7506	**4562**
Service Area 27													
E00042262	170	183	**0.93**	174	**162**	123	**114**	51	**47**	64	**59**	470	**437**
E00042263	157	157	**1.00**	152	**152**	94	**94**	58	**58**	44	**44**	296	**296**
E00042264	128	128	**1.00**	132	**132**	85	**85**	47	**47**	51	**51**	237	**237**
E00042265	151	151	**1.00**	140	**140**	95	**95**	45	**45**	56	**56**	310	**310**
E00042266	183	183	**1.00**	173	**173**	122	**122**	51	**51**	78	**78**	434	**434**
E00042267	140	140	**1.00**	123	**123**	80	**80**	43	**43**	56	**56**	345	**345**
E00042268	71	114	**0.62**	111	**69**	78	**49**	33	**21**	33	**21**	210	**131**
E00042269	168	181	**0.93**	158	**147**	123	**114**	35	**32**	63	**58**	342	**317**
E00042270	149	149	**1.00**	137	**137**	91	**91**	46	**46**	52	**52**	348	**348**
E00042271	63	129	**0.49**	131	**64**	74	**36**	57	**28**	61	**30**	384	**188**
E00042273	94	138	**0.68**	128	**87**	91	**62**	37	**25**	59	**40**	404	**275**
E00042274	117	134	**0.87**	125	**109**	90	**79**	35	**31**	45	**39**	246	**215**
E00042275	3	129	**0.02**	128	**3**	83	**2**	45	**1**	65	**2**	403	**9**
E00042278	64	142	**0.45**	115	**52**	104	**47**	11	**5**	42	**19**	214	**96**

E00042280	172	201	**0.86**	177	**151**	135	**116**	42	**36**	62	**53**	432	**370**
E00042281	8	141	**0.06**	133	**8**	79	**4**	54	**3**	57	**3**	296	**17**
E00042345	8	114	**0.07**	106	**7**	65	**5**	41	**3**	49	**3**	245	**17**
E00042348	70	97	**0.72**	95	**69**	70	**51**	25	**18**	40	**29**	269	**194**
E00042350	28	141	**0.20**	133	**26**	74	**15**	59	**12**	66	**13**	342	**68**
E00042351	6	102	**0.06**	96	**6**	65	**4**	31	**2**	42	**2**	239	**14**
E00042354	113	117	**0.97**	114	**110**	74	**71**	40	**39**	43	**42**	282	**272**
E00042355	118	118	**1.00**	122	**122**	74	**74**	48	**48**	48	**48**	307	**307**
E00042356	121	121	**1.00**	122	**122**	70	**70**	52	**52**	45	**45**	369	**369**
E00042357	129	129	**1.00**	124	**124**	80	**80**	44	**44**	77	**77**	394	**394**
E00042875	101	165	**0.61**	125	**77**	79	**48**	46	**28**	39	**24**	321	**196**
E00042878	27	144	**0.19**	129	**24**	74	**14**	55	**10**	88	**17**	399	**75**
E00042879	122	122	**1.00**	122	**122**	85	**85**	37	**37**	52	**52**	378	**378**
E00042893	3	117	**0.03**	116	**3**	57	**1**	59	**2**	43	**1**	270	**7**
E00042897	48	122	**0.39**	117	**46**	52	**20**	65	**26**	106	**42**	292	**115**
E00042902	127	127	**1.00**	123	**123**	73	**73**	50	**50**	62	**62**	310	**310**
Subtotal 27				3881	**2689**	2539	**1801**	1342	**889**	1688	**1118**	9788	**6741**
Service Area 28													
E00042087	8	123	**0.07**	112	**7**	85	**6**	27	**2**	46	**3**	258	**17**
E00042089	11	128	**0.09**	121	**10**	113	**10**	8	**1**	33	**3**	161	**14**
E00042323	146	146	**1.00**	141	**141**	80	**80**	61	**61**	45	**45**	271	**271**
E00042325	124	146	**0.85**	119	**101**	74	**63**	45	**38**	42	**36**	215	**183**
E00042328	80	139	**0.58**	137	**79**	86	**49**	51	**29**	58	**33**	311	**179**
E00042339	149	149	**1.00**	146	**146**	112	**112**	34	**34**	50	**50**	268	**268**
E00042340	121	121	**1.00**	111	**111**	78	**78**	33	**33**	30	**30**	246	**246**
E00042341	85	111	**0.77**	108	**83**	55	**42**	53	**41**	38	**29**	230	**176**
E00042342	7	115	**0.06**	113	**7**	69	**4**	44	**3**	39	**2**	245	**15**
E00042344	98	106	**0.92**	102	**94**	51	**47**	51	**47**	20	**18**	182	**168**
E00042345	93	114	**0.82**	106	**86**	65	**53**	41	**33**	49	**40**	245	**200**
E00042348	14	97	**0.14**	95	**14**	70	**10**	25	**4**	40	**6**	269	**39**
E00042349	90	133	**0.68**	132	**89**	70	**47**	62	**42**	55	**37**	334	**226**
E00042350	43	141	**0.30**	133	**41**	74	**23**	59	**18**	66	**20**	342	**104**
E00042351	43	102	**0.42**	96	**40**	65	**27**	31	**13**	42	**18**	239	**101**
E00042352	32	110	**0.29**	109	**32**	87	**25**	22	**6**	47	**14**	246	**72**

E00042354	6	117	**0.05**	114	**6**	74	**4**	40	**2**	43	**2**	282	**14**
E00042876	22	130	**0.17**	126	**21**	68	**12**	58	**10**	49	**8**	356	**60**
E00042881	95	142	**0.67**	128	**86**	66	**44**	62	**41**	27	**18**	251	**168**
E00042882	131	135	**0.97**	135	**131**	99	**96**	36	**35**	51	**49**	337	**327**
E00042883	58	157	**0.37**	154	**57**	96	**35**	58	**21**	48	**18**	305	**113**
E00042884	140	140	**1.00**	129	**129**	68	**68**	61	**61**	35	**35**	209	**209**
E00042885	61	137	**0.45**	133	**59**	82	**37**	51	**23**	40	**18**	249	**111**
E00042886	162	162	**1.00**	160	**160**	75	**75**	85	**85**	44	**44**	236	**236**
E00042887	149	149	**1.00**	135	**135**	85	**85**	50	**50**	58	**58**	288	**288**
E00042888	143	143	**1.00**	145	**145**	97	**97**	48	**48**	50	**50**	289	**289**
E00042889	3	146	**0.02**	144	**3**	81	**2**	63	**1**	64	**1**	342	**7**
E00042890	167	167	**1.00**	159	**159**	116	**116**	43	**43**	70	**70**	336	**336**
E00042891	47	117	**0.40**	113	**45**	31	**12**	82	**33**	35	**14**	231	**93**
E00042892	135	135	**1.00**	135	**135**	98	**98**	37	**37**	62	**62**	285	**285**
E00042893	64	117	**0.55**	116	**63**	57	**31**	59	**32**	43	**24**	270	**148**
E00042894	129	130	**0.99**	112	**111**	68	**67**	44	**44**	54	**54**	306	**304**
E00175596	96	98	**0.98**	100	**98**	75	**73**	25	**24**	34	**33**	245	**240**
E00175598	36	98	**0.37**	88	**32**	40	**15**	48	**18**	4	**1**	608	**223**
Subtotal 28				4207	**2658**	2610	**1644**	1597	**1014**	1511	**944**	9487	**5729**
Service Area 29													
E00042229	90	121	**0.74**	123	**91**	62	**46**	61	**45**	36	**27**	226	**168**
E00042236	65	109	**0.60**	112	**67**	73	**44**	39	**23**	49	**29**	178	**106**
E00042248	19	119	**0.16**	120	**19**	56	**9**	64	**10**	46	**7**	226	**36**
E00042249	116	116	**1.00**	116	**116**	66	**66**	50	**50**	51	**51**	200	**200**
E00042250	110	110	**1.00**	111	**111**	61	**61**	50	**50**	46	**46**	212	**212**
E00042253	113	113	**1.00**	117	**117**	67	**67**	50	**50**	60	**60**	200	**200**
E00042257	92	116	**0.79**	116	**92**	70	**56**	46	**36**	59	**47**	208	**165**
E00042259	20	114	**0.18**	111	**19**	55	**10**	56	**10**	51	**9**	243	**43**
E00042834	14	112	**0.13**	112	**14**	47	**6**	65	**8**	22	**3**	273	**34**
E00042835	119	119	**1.00**	122	**122**	68	**68**	54	**54**	50	**50**	213	**213**
E00042837	4	126	**0.03**	125	**4**	56	**2**	69	**2**	42	**1**	240	**8**
E00042839	121	121	**1.00**	120	**120**	78	**78**	42	**42**	56	**56**	192	**192**
E00042842	40	120	**0.33**	119	**40**	64	**21**	55	**18**	44	**15**	224	**75**
E00042845	102	119	**0.86**	117	**100**	65	**56**	52	**45**	58	**50**	187	**160**

E00042846	132	132	**1.00**	132	**132**	87	**87**	45	**45**	60	**60**	199	**199**
E00042847	36	124	**0.29**	124	**36**	65	**19**	59	**17**	50	**15**	246	**71**
E00042854	131	131	**1.00**	117	**117**	74	**74**	43	**43**	53	**53**	194	**194**
E00042855	125	125	**1.00**	121	**121**	66	**66**	55	**55**	43	**43**	215	**215**
E00042856	120	122	**0.98**	122	**120**	67	**66**	55	**54**	45	**44**	226	**222**
E00042858	107	125	**0.86**	125	**107**	66	**56**	59	**51**	48	**41**	240	**205**
E00042859	39	129	**0.30**	133	**40**	53	**16**	80	**24**	30	**9**	310	**94**
E00042862	129	129	**1.00**	123	**123**	80	**80**	43	**43**	58	**58**	190	**190**
E00042871	38	128	**0.30**	128	**38**	68	**20**	60	**18**	36	**11**	246	**73**
Subtotal 29				2766	**1867**	1514	**1073**	1252	**794**	1093	**784**	5088	**3276**
Service Area 30													
E00042229	93	121	**0.77**	123	**95**	62	**48**	61	**47**	36	**28**	226	**174**
E00042236	52	109	**0.48**	112	**53**	73	**35**	39	**19**	49	**23**	178	**85**
E00042248	14	119	**0.12**	120	**14**	56	**7**	64	**8**	46	**5**	226	**27**
E00042249	116	116	**1.00**	116	**116**	66	**66**	50	**50**	51	**51**	200	**200**
E00042250	110	110	**1.00**	111	**111**	61	**61**	50	**50**	46	**46**	212	**212**
E00042253	113	113	**1.00**	117	**117**	67	**67**	50	**50**	60	**60**	200	**200**
E00042257	86	116	**0.74**	116	**86**	70	**52**	46	**34**	59	**44**	208	**154**
E00042259	14	114	**0.12**	111	**14**	55	**7**	56	**7**	51	**6**	243	**30**
E00042834	14	112	**0.13**	112	**14**	47	**6**	65	**8**	22	**3**	273	**34**
E00042835	119	119	**1.00**	122	**122**	68	**68**	54	**54**	50	**50**	213	**213**
E00042837	6	126	**0.05**	125	**6**	56	**3**	69	**3**	42	**2**	240	**11**
E00042839	121	121	**1.00**	120	**120**	78	**78**	42	**42**	56	**56**	192	**192**
E00042842	40	120	**0.33**	119	**40**	64	**21**	55	**18**	44	**15**	224	**75**
E00042845	102	119	**0.86**	117	**100**	65	**56**	52	**45**	58	**50**	187	**160**
E00042846	132	132	**1.00**	132	**132**	87	**87**	45	**45**	60	**60**	199	**199**
E00042847	35	124	**0.28**	124	**35**	65	**18**	59	**17**	50	**14**	246	**69**
E00042854	131	131	**1.00**	117	**117**	74	**74**	43	**43**	53	**53**	194	**194**
E00042855	125	125	**1.00**	121	**121**	66	**66**	55	**55**	43	**43**	215	**215**
E00042856	115	122	**0.94**	122	**115**	67	**63**	55	**52**	45	**42**	226	**213**
E00042858	106	125	**0.85**	125	**106**	66	**56**	59	**50**	48	**41**	240	**204**
E00042859	37	129	**0.29**	133	**38**	53	**15**	80	**23**	30	**9**	310	**89**
E00042862	129	129	**1.00**	123	**123**	80	**80**	43	**43**	58	**58**	190	**190**
E00042871	37	128	**0.29**	128	**37**	68	**20**	60	**17**	36	**10**	246	**71**

Subtotal 30				2766	**1832**	1514	**1053**	1252	**779**	1093	**769**	5088	**3211**
Service Area 31													
E00042228	45	157	**0.29**	193	**55**	147	**42**	46	**13**	120	**34**	304	**87**
E00042246	78	101	**0.77**	97	**75**	69	**53**	28	**22**	36	**28**	199	**154**
E00042251	7	124	**0.06**	124	**7**	85	**5**	39	**2**	55	**3**	310	**18**
E00042252	4	132	**0.03**	129	**4**	110	**3**	19	**1**	66	**2**	155	**5**
E00042255	16	133	**0.12**	133	**16**	92	**11**	41	**5**	49	**6**	277	**33**
E00042831	155	165	**0.94**	134	**126**	96	**90**	38	**36**	93	**87**	264	**248**
E00042833	55	164	**0.34**	142	**48**	94	**32**	48	**16**	40	**13**	291	**98**
E00042836	112	112	**1.00**	118	**118**	69	**69**	49	**49**	43	**43**	266	**266**
E00042841	18	119	**0.15**	113	**17**	77	**12**	36	**5**	33	**5**	195	**29**
E00042843	141	141	**1.00**	145	**145**	100	**100**	45	**45**	67	**67**	245	**245**
E00042850	61	132	**0.46**	130	**60**	96	**44**	34	**16**	39	**18**	217	**100**
E00042851	127	127	**1.00**	129	**129**	79	**79**	50	**50**	37	**37**	258	**258**
E00042857	148	148	**1.00**	140	**140**	79	**79**	61	**61**	34	**34**	309	**309**
E00042863	137	137	**1.00**	134	**134**	83	**83**	51	**51**	49	**49**	265	**265**
E00042907	48	154	**0.31**	154	**48**	114	**36**	40	**12**	59	**18**	252	**79**
E00042908	54	130	**0.42**	141	**59**	96	**40**	45	**19**	36	**15**	272	**113**
E00042909	50	105	**0.48**	158	**75**	112	**53**	46	**22**	51	**24**	213	**101**
E00042928	30	171	**0.18**	168	**29**	117	**21**	51	**9**	48	**8**	300	**53**
Subtotal 31				2482	**1285**	1715	**852**	767	**433**	955	**493**	4592	**2460**
Service Area 32													
E00042228	17	157	**0.11**	193	**21**	147	**16**	46	**5**	120	**13**	304	**33**
E00042229	88	121	**0.73**	123	**89**	62	**45**	61	**44**	36	**26**	226	**164**
E00042233	135	135	**1.00**	133	**133**	88	**88**	45	**45**	47	**47**	257	**257**
E00042234	18	130	**0.14**	117	**16**	59	**8**	58	**8**	75	**10**	265	**37**
E00042235	18	118	**0.15**	117	**18**	67	**10**	50	**8**	36	**5**	254	**39**
E00042237	31	45	**0.69**	44	**30**	33	**23**	11	**8**	19	**13**	100	**69**
E00042238	45	124	**0.36**	124	**45**	90	**33**	34	**12**	52	**19**	314	**114**
E00042240	134	134	**1.00**	130	**130**	101	**101**	29	**29**	49	**49**	238	**238**
E00042241	52	125	**0.42**	123	**51**	95	**40**	28	**12**	58	**24**	194	**81**
E00042242	87	121	**0.72**	125	**90**	89	**64**	36	**26**	43	**31**	234	**168**
E00042243	91	113	**0.81**	112	**90**	72	**58**	40	**32**	32	**26**	225	**181**
E00042244	39	130	**0.30**	129	**39**	75	**23**	54	**16**	52	**16**	277	**83**

E00042247	124	124	**1.00**	122	**122**	113	**113**	9	**9**	82	**82**	80	**80**
E00042254	133	133	**1.00**	133	**133**	79	**79**	54	**54**	31	**31**	251	**251**
E00042255	74	133	**0.56**	133	**74**	92	**51**	41	**23**	49	**27**	277	**154**
E00042256	128	140	**0.91**	140	**128**	102	**93**	38	**35**	52	**48**	271	**248**
E00042258	135	135	**1.00**	132	**132**	100	**100**	32	**32**	27	**27**	262	**262**
E00042260	1	130	**0.01**	130	**1**	94	**1**	36	**0**	42	**0**	344	**3**
E00042261	146	146	**1.00**	145	**145**	108	**108**	37	**37**	53	**53**	227	**227**
E00042832	13	96	**0.14**	124	**17**	91	**12**	33	**4**	62	**8**	206	**28**
E00042833	23	164	**0.14**	142	**20**	94	**13**	48	**7**	40	**6**	291	**41**
E00042853	107	125	**0.86**	123	**105**	80	**68**	43	**37**	56	**48**	195	**167**
E00042859	3	129	**0.02**	133	**3**	53	**1**	80	**2**	30	**1**	310	**7**
E00042860	61	133	**0.46**	127	**58**	81	**37**	46	**21**	62	**28**	206	**94**
E00042861	114	139	**0.82**	134	**110**	87	**71**	47	**39**	48	**39**	214	**176**
Subtotal 32				3188	**1801**	2152	**1257**	1036	**544**	1253	**678**	6022	**3201**
Service Area 33													
E00042048	33	137	**0.24**	146	**35**	76	**18**	70	**17**	58	**14**	297	**72**
E00042245	27	189	**0.14**	195	**28**	117	**17**	78	**11**	79	**11**	372	**53**
E00042324	167	167	**1.00**	158	**158**	98	**98**	60	**60**	52	**52**	281	**281**
E00042329	18	131	**0.14**	134	**18**	103	**14**	31	**4**	21	**3**	175	**24**
E00042330	91	120	**0.76**	120	**91**	92	**70**	28	**21**	39	**30**	168	**127**
E00042334	79	150	**0.53**	140	**74**	108	**57**	32	**17**	46	**24**	235	**124**
E00042335	145	145	**1.00**	142	**142**	100	**100**	42	**42**	44	**44**	275	**275**
E00042336	117	117	**1.00**	155	**155**	116	**116**	39	**39**	75	**75**	180	**180**
E00042337	111	142	**0.78**	139	**109**	93	**73**	46	**36**	60	**47**	250	**195**
E00042338	159	159	**1.00**	160	**160**	109	**109**	51	**51**	64	**64**	330	**330**
E00042343	6	133	**0.05**	131	**6**	85	**4**	46	**2**	52	**2**	245	**11**
E00042347	131	152	**0.86**	151	**130**	104	**90**	47	**41**	42	**36**	270	**233**
E00042513	8	128	**0.06**	124	**8**	81	**5**	43	**3**	49	**3**	252	**16**
E00042540	17	134	**0.13**	130	**16**	86	**11**	44	**6**	52	**7**	210	**27**
E00042686	96	122	**0.79**	121	**95**	73	**57**	48	**38**	43	**34**	243	**191**
E00042687	90	116	**0.78**	122	**95**	75	**58**	47	**36**	40	**31**	266	**206**
E00042688	39	114	**0.34**	114	**39**	65	**22**	49	**17**	24	**8**	222	**76**
E00042689	44	140	**0.31**	134	**42**	89	**28**	45	**14**	40	**13**	301	**95**
E00042702	117	117	**1.00**	119	**119**	79	**79**	40	**40**	23	**23**	246	**246**

E00042703	120	120	**1.00**	120	**120**	67	**67**	53	**53**	31	**31**	219	**219**
E00042704	108	121	**0.89**	125	**112**	64	**57**	61	**54**	34	**30**	285	**254**
E00042705	123	123	**1.00**	121	**121**	65	**65**	56	**56**	32	**32**	228	**228**
Subtotal 33				3001	**1873**	1945	**1215**	1056	**658**	1000	**614**	5550	**3463**
Service Area 34													
E00042087	76	123	**0.62**	112	**69**	85	**53**	27	**17**	46	**28**	258	**159**
E00042088	132	141	**0.94**	142	**133**	71	**66**	71	**66**	38	**36**	322	**301**
E00042089	103	128	**0.80**	121	**97**	113	**91**	8	**6**	33	**27**	161	**130**
E00042090	13	134	**0.10**	122	**12**	84	**8**	38	**4**	40	**4**	227	**22**
E00042100	117	117	**1.00**	115	**115**	67	**67**	48	**48**	92	**92**	235	**235**
E00042101	5	122	**0.04**	117	**5**	100	**4**	17	**1**	45	**2**	198	**8**
E00042104	142	180	**0.79**	175	**138**	117	**92**	58	**46**	70	**55**	418	**330**
E00042478	149	149	**1.00**	146	**146**	108	**108**	38	**38**	37	**37**	330	**330**
E00042479	158	158	**1.00**	135	**135**	116	**116**	19	**19**	64	**64**	247	**247**
E00042481	6	115	**0.05**	112	**6**	71	**4**	41	**2**	40	**2**	323	**17**
E00042503	69	131	**0.53**	118	**62**	85	**45**	33	**17**	42	**22**	325	**171**
E00042505	100	115	**0.87**	109	**95**	65	**57**	44	**38**	32	**28**	228	**198**
E00042507	153	185	**0.83**	179	**148**	148	**122**	31	**26**	64	**53**	403	**333**
E00042508	154	154	**1.00**	135	**135**	94	**94**	41	**41**	36	**36**	159	**159**
E00042509	167	167	**1.00**	144	**144**	104	**104**	40	**40**	66	**66**	296	**296**
E00042876	69	130	**0.53**	126	**67**	68	**36**	58	**31**	49	**26**	356	**189**
E00042880	15	124	**0.12**	114	**14**	55	**7**	59	**7**	40	**5**	312	**38**
E00042881	100	142	**0.70**	128	**90**	66	**46**	62	**44**	27	**19**	251	**177**
E00042882	78	135	**0.58**	135	**78**	99	**57**	36	**21**	51	**29**	337	**195**
E00042884	97	140	**0.69**	129	**89**	68	**47**	61	**42**	35	**24**	209	**145**
E00042886	31	162	**0.19**	160	**31**	75	**14**	85	**16**	44	**8**	236	**45**
E00042888	43	143	**0.30**	145	**44**	97	**29**	48	**14**	50	**15**	289	**87**
E00175603	19	93	**0.20**	92	**19**	49	**10**	43	**9**	36	**7**	223	**46**
Subtotal 34				3011	**1871**	2005	**1278**	1006	**593**	1077	**686**	6343	**3857**
Service Area 35													
E00042086	76	131	**0.58**	127	**74**	87	**50**	40	**23**	29	**17**	306	**178**
E00042087	1	123	**0.01**	112	**1**	85	**1**	27	**0**	46	**0**	258	**2**
E00042088	135	141	**0.96**	142	**136**	71	**68**	71	**68**	38	**36**	322	**308**
E00042089	28	128	**0.22**	121	**26**	113	**25**	8	**2**	33	**7**	161	**35**

E00042090	64	134	**0.48**	122	**58**	84	**40**	38	**18**	40	**19**	227	**108**
E00042091	115	128	**0.90**	128	**115**	94	**84**	34	**31**	45	**40**	317	**285**
E00042100	115	117	**0.98**	115	**113**	67	**66**	48	**47**	92	**90**	235	**231**
E00042101	122	122	**1.00**	117	**117**	100	**100**	17	**17**	45	**45**	198	**198**
E00042102	5	152	**0.03**	139	**5**	100	**3**	39	**1**	53	**2**	346	**11**
E00042103	134	134	**1.00**	131	**131**	101	**101**	30	**30**	43	**43**	280	**280**
E00042104	180	180	**1.00**	175	**175**	117	**117**	58	**58**	70	**70**	418	**418**
E00042106	122	122	**1.00**	118	**118**	89	**89**	29	**29**	42	**42**	321	**321**
E00042333	9	126	**0.07**	120	**9**	84	**6**	36	**3**	45	**3**	244	**17**
E00042478	144	149	**0.97**	146	**141**	108	**104**	38	**37**	37	**36**	330	**319**
E00042479	99	158	**0.63**	135	**85**	116	**73**	19	**12**	64	**40**	247	**155**
E00042481	24	115	**0.21**	112	**23**	71	**15**	41	**9**	40	**8**	323	**67**
E00042503	126	131	**0.96**	118	**113**	85	**82**	33	**32**	42	**40**	325	**313**
E00042505	115	115	**1.00**	109	**109**	65	**65**	44	**44**	32	**32**	228	**228**
E00042507	173	185	**0.94**	179	**167**	148	**138**	31	**29**	64	**60**	403	**377**
E00042509	34	167	**0.20**	144	**29**	104	**21**	40	**8**	66	**13**	296	**60**
E00042883	14	157	**0.09**	154	**14**	96	**9**	58	**5**	48	**4**	305	**27**
E00042885	44	137	**0.32**	133	**43**	82	**26**	51	**16**	40	**13**	249	**80**
E00175603	54	93	**0.58**	92	**53**	49	**28**	43	**25**	36	**21**	223	**129**
Subtotal 35				2989	**1856**	2116	**1312**	873	**543**	1090	**684**	6562	**4149**
Service Area 36													
E00042070	91	114	**0.80**	112	**89**	70	**56**	42	**34**	37	**30**	250	**200**
E00042077	7	114	**0.06**	111	**7**	53	**3**	58	**4**	25	**2**	220	**14**
E00042078	90	131	**0.69**	130	**89**	64	**44**	66	**45**	32	**22**	224	**154**
E00042079	15	117	**0.13**	116	**15**	79	**10**	37	**5**	23	**3**	221	**28**
E00042080	125	126	**0.99**	122	**121**	90	**89**	32	**32**	34	**34**	214	**212**
E00042904	126	126	**1.00**	123	**123**	101	**101**	22	**22**	50	**50**	269	**269**
E00042905	90	99	**0.91**	119	**108**	93	**85**	26	**24**	25	**23**	175	**159**
E00042906	93	128	**0.73**	130	**94**	105	**76**	25	**18**	51	**37**	221	**161**
E00042907	5	154	**0.03**	154	**5**	114	**4**	40	**1**	59	**2**	252	**8**
E00042908	80	130	**0.62**	141	**87**	96	**59**	45	**28**	36	**22**	272	**167**
E00042909	53	105	**0.50**	158	**80**	112	**57**	46	**23**	51	**26**	213	**108**
E00042916	71	119	**0.60**	113	**67**	88	**53**	25	**15**	100	**60**	287	**171**
E00042918	17	127	**0.13**	127	**17**	95	**13**	32	**4**	42	**6**	320	**43**

E00042919	142	142	**1.00**	137	**137**	95	**95**	42	**42**	53	**53**	306	**306**
E00042920	118	118	**1.00**	118	**118**	88	**88**	30	**30**	71	**71**	303	**303**
E00042921	44	129	**0.34**	125	**43**	102	**35**	23	**8**	52	**18**	284	**97**
E00042922	27	118	**0.23**	116	**27**	91	**21**	25	**6**	51	**12**	242	**55**
E00042923	29	123	**0.24**	126	**30**	65	**15**	61	**14**	33	**8**	255	**60**
E00042924	110	110	**1.00**	111	**111**	82	**82**	29	**29**	48	**48**	211	**211**
E00042925	101	101	**1.00**	121	**121**	101	**101**	20	**20**	60	**60**	191	**191**
E00042926	116	120	**0.97**	116	**112**	90	**87**	26	**25**	63	**61**	240	**232**
E00042927	108	108	**1.00**	120	**120**	102	**102**	18	**18**	41	**41**	227	**227**
E00042930	109	109	**1.00**	105	**105**	57	**57**	48	**48**	22	**22**	177	**177**
Subtotal 36				2851	**1826**	2033	**1332**	818	**494**	1059	**708**	5574	**3553**
Service Area 37													
E00042107	32	122	**0.26**	125	**33**	100	**26**	25	**7**	42	**11**	221	**58**
E00042108	6	144	**0.04**	141	**6**	114	**5**	27	**1**	50	**2**	260	**11**
E00042111	110	110	**1.00**	136	**136**	105	**105**	31	**31**	44	**44**	183	**183**
E00042112	141	141	**1.00**	155	**155**	125	**125**	30	**30**	45	**45**	235	**235**
E00042125	131	131	**1.00**	131	**131**	99	**99**	32	**32**	15	**15**	193	**193**
E00042126	154	185	**0.83**	231	**192**	186	**155**	45	**37**	33	**27**	295	**246**
E00042127	142	142	**1.00**	147	**147**	103	**103**	44	**44**	34	**34**	308	**308**
E00042128	108	108	**1.00**	125	**125**	92	**92**	33	**33**	29	**29**	139	**139**
E00042129	210	210	**1.00**	200	**200**	156	**156**	44	**44**	68	**68**	398	**398**
E00042130	18	130	**0.14**	135	**19**	115	**16**	20	**3**	48	**7**	232	**32**
E00042131	32	130	**0.25**	140	**34**	113	**28**	27	**7**	32	**8**	184	**45**
E00042132	96	135	**0.71**	134	**95**	102	**73**	32	**23**	15	**11**	210	**149**
E00042133	21	58	**0.36**	157	**57**	117	**42**	40	**14**	28	**10**	251	**91**
E00042134	54	130	**0.42**	140	**58**	101	**42**	39	**16**	34	**14**	265	**110**
E00042136	96	154	**0.62**	150	**94**	117	**73**	33	**21**	42	**26**	243	**151**
E00042412	2	117	**0.02**	120	**2**	57	**1**	63	**1**	7	**0**	349	**6**
E00042413	18	138	**0.13**	129	**17**	68	**9**	61	**8**	13	**2**	350	**46**
E00042414	84	122	**0.69**	98	**67**	38	**26**	60	**41**	10	**7**	222	**153**
E00042415	90	172	**0.52**	153	**80**	79	**41**	74	**39**	17	**9**	311	**163**
E00042433	8	86	**0.09**	81	**8**	34	**3**	47	**4**	12	**1**	225	**21**
E00042434	137	137	**1.00**	133	**133**	67	**67**	66	**66**	24	**24**	235	**235**
E00042435	135	135	**1.00**	133	**133**	69	**69**	64	**64**	18	**18**	336	**336**

E00042436	117	117	**1.00**	110	**110**	49	**49**	61	**61**	10	**10**	222	**222**
E00042437	134	134	**1.00**	131	**131**	69	**69**	62	**62**	26	**26**	291	**291**
E00042438	157	157	**1.00**	125	**125**	66	**66**	59	**59**	12	**12**	389	**389**
E00042652	95	121	**0.79**	116	**91**	44	**35**	72	**57**	17	**13**	201	**158**
E00042656	134	138	**0.97**	136	**132**	52	**50**	84	**82**	31	**30**	327	**318**
E00042657	69	150	**0.46**	141	**65**	52	**24**	89	**41**	26	**12**	382	**176**
E00042658	136	136	**1.00**	123	**123**	61	**61**	62	**62**	18	**18**	353	**353**
E00042659	133	133	**1.00**	126	**126**	45	**45**	81	**81**	24	**24**	349	**349**
E00042664	140	140	**1.00**	127	**127**	80	**80**	47	**47**	20	**20**	249	**249**
E00042666	13	150	**0.09**	147	**13**	91	**8**	56	**5**	16	**1**	318	**28**
E00042668	43	125	**0.34**	122	**42**	63	**22**	59	**20**	10	**3**	271	**93**
Subtotal 37				4498	**3007**	2829	**1864**	1669	**1142**	870	**582**	8997	**5934**
Service Area 38													
E00042107	19	122	**0.16**	125	**19**	100	**16**	25	**4**	42	**7**	221	**34**
E00042108	14	144	**0.10**	141	**14**	114	**11**	27	**3**	50	**5**	260	**25**
E00042111	106	110	**0.96**	136	**131**	105	**101**	31	**30**	44	**42**	183	**176**
E00042112	137	141	**0.97**	155	**151**	125	**121**	30	**29**	45	**44**	235	**228**
E00042114	15	151	**0.10**	154	**15**	86	**9**	68	**7**	20	**2**	236	**23**
E00042115	99	159	**0.62**	138	**86**	117	**73**	21	**13**	48	**30**	251	**156**
E00042125	131	131	**1.00**	131	**131**	99	**99**	32	**32**	15	**15**	193	**193**
E00042126	159	185	**0.86**	231	**199**	186	**160**	45	**39**	33	**28**	295	**254**
E00042127	142	142	**1.00**	147	**147**	103	**103**	44	**44**	34	**34**	308	**308**
E00042128	108	108	**1.00**	125	**125**	92	**92**	33	**33**	29	**29**	139	**139**
E00042129	210	210	**1.00**	200	**200**	156	**156**	44	**44**	68	**68**	398	**398**
E00042131	3	130	**0.02**	140	**3**	113	**3**	27	**1**	32	**1**	184	**4**
E00042132	135	135	**1.00**	134	**134**	102	**102**	32	**32**	15	**15**	210	**210**
E00042133	9	58	**0.16**	157	**24**	117	**18**	40	**6**	28	**4**	251	**39**
E00042134	130	130	**1.00**	140	**140**	101	**101**	39	**39**	34	**34**	265	**265**
E00042136	149	154	**0.97**	150	**145**	117	**113**	33	**32**	42	**41**	243	**235**
E00042435	7	135	**0.05**	133	**7**	69	**4**	64	**3**	18	**1**	336	**17**
E00042437	53	134	**0.40**	131	**52**	69	**27**	62	**25**	26	**10**	291	**115**
E00042438	153	157	**0.97**	125	**122**	66	**64**	59	**57**	12	**12**	389	**379**
E00042643	109	153	**0.71**	151	**108**	76	**54**	75	**53**	28	**20**	413	**294**
E00042647	85	97	**0.88**	95	**83**	49	**43**	46	**40**	15	**13**	203	**178**

E00042652	9	121	**0.07**	116	**9**	44	**3**	72	**5**	17	**1**	201	**15**
E00042656	114	138	**0.83**	136	**112**	52	**43**	84	**69**	31	**26**	327	**270**
E00042657	150	150	**1.00**	141	**141**	52	**52**	89	**89**	26	**26**	382	**382**
E00042658	136	136	**1.00**	123	**123**	61	**61**	62	**62**	18	**18**	353	**353**
E00042659	133	133	**1.00**	126	**126**	45	**45**	81	**81**	24	**24**	349	**349**
E00042662	123	123	**1.00**	118	**118**	53	**53**	65	**65**	12	**12**	288	**288**
E00042663	1	94	**0.01**	92	**1**	46	**0**	46	**0**	13	**0**	219	**2**
E00042664	140	140	**1.00**	127	**127**	80	**80**	47	**47**	20	**20**	249	**249**
E00042666	150	150	**1.00**	147	**147**	91	**91**	56	**56**	16	**16**	318	**318**
E00042667	24	79	**0.30**	80	**24**	31	**9**	49	**15**	6	**2**	192	**58**
E00042668	125	125	**1.00**	122	**122**	63	**63**	59	**59**	10	**10**	271	**271**
E00175556	1	50	**0.02**	75	**2**	51	**1**	24	**0**	19	**0**	105	**2**
Subtotal 38				4442	**3087**	2831	**1972**	1611	**1115**	890	**610**	8758	**6231**
Service Area 39													
E00042107	18	122	**0.15**	125	**18**	100	**15**	25	**4**	42	**6**	221	**33**
E00042108	16	144	**0.11**	141	**16**	114	**13**	27	**3**	50	**6**	260	**29**
E00042111	106	110	**0.96**	136	**131**	105	**101**	31	**30**	44	**42**	183	**176**
E00042112	137	141	**0.97**	155	**151**	125	**121**	30	**29**	45	**44**	235	**228**
E00042114	14	110	**0.13**	154	**20**	86	**11**	68	**9**	20	**3**	236	**30**
E00042115	79	141	**0.56**	138	**77**	117	**66**	21	**12**	48	**27**	251	**141**
E00042125	131	131	**1.00**	131	**131**	99	**99**	32	**32**	15	**15**	193	**193**
E00042126	157	185	**0.85**	231	**196**	186	**158**	45	**38**	33	**28**	295	**250**
E00042127	142	142	**1.00**	147	**147**	103	**103**	44	**44**	34	**34**	308	**308**
E00042128	108	108	**1.00**	125	**125**	92	**92**	33	**33**	29	**29**	139	**139**
E00042129	210	210	**1.00**	200	**200**	156	**156**	44	**44**	68	**68**	398	**398**
E00042131	3	130	**0.02**	140	**3**	113	**3**	27	**1**	32	**1**	184	**4**
E00042132	135	135	**1.00**	134	**134**	102	**102**	32	**32**	15	**15**	210	**210**
E00042134	130	130	**1.00**	140	**140**	101	**101**	39	**39**	34	**34**	265	**265**
E00042136	148	154	**0.96**	150	**144**	117	**112**	33	**32**	42	**40**	243	**234**
E00042435	7	135	**0.05**	133	**7**	69	**4**	64	**3**	18	**1**	336	**17**
E00042437	51	134	**0.38**	131	**50**	69	**26**	62	**24**	26	**10**	291	**111**
E00042438	153	157	**0.97**	125	**122**	66	**64**	59	**57**	12	**12**	389	**379**
E00042643	107	153	**0.70**	151	**106**	76	**53**	75	**52**	28	**20**	413	**289**
E00042647	85	97	**0.88**	95	**83**	49	**43**	46	**40**	15	**13**	203	**178**

E00042652	9	121	**0.07**	116	**9**	44	**3**	72	**5**	17	**1**	201	**15**
E00042656	118	138	**0.86**	136	**116**	52	**44**	84	**72**	31	**27**	327	**280**
E00042657	150	150	**1.00**	141	**141**	52	**52**	89	**89**	26	**26**	382	**382**
E00042658	136	136	**1.00**	123	**123**	61	**61**	62	**62**	18	**18**	353	**353**
E00042659	133	133	**1.00**	126	**126**	45	**45**	81	**81**	24	**24**	349	**349**
E00042662	123	123	**1.00**	118	**118**	53	**53**	65	**65**	12	**12**	288	**288**
E00042663	1	94	**0.01**	92	**1**	46	**0**	46	**0**	13	**0**	219	**2**
E00042664	140	140	**1.00**	127	**127**	80	**80**	47	**47**	20	**20**	249	**249**
E00042666	150	150	**1.00**	147	**147**	91	**91**	56	**56**	16	**16**	318	**318**
E00042667	15	79	**0.19**	80	**15**	31	**6**	49	**9**	6	**1**	192	**36**
E00042668	125	125	**1.00**	122	**122**	63	**63**	59	**59**	10	**10**	271	**271**
E00175556	1	50	**0.02**	75	**2**	51	**1**	24	**0**	19	**0**	105	**2**
Subtotal 39				4285	**3047**	2714	**1943**	1571	**1104**	862	**602**	8507	**6157**
Service Area 40													
E00042120	17	148	**0.11**	152	**17**	111	**13**	41	**5**	43	**5**	299	**34**
E00042122	19	146	**0.13**	127	**17**	82	**11**	45	**6**	25	**3**	232	**30**
E00042549	98	156	**0.63**	152	**95**	109	**68**	43	**27**	52	**33**	334	**210**
E00042550	143	143	**1.00**	142	**142**	115	**115**	27	**27**	36	**36**	282	**282**
E00042551	135	135	**1.00**	128	**128**	108	**108**	20	**20**	43	**43**	253	**253**
E00042552	105	117	**0.90**	115	**103**	102	**92**	13	**12**	46	**41**	124	**111**
E00042553	140	140	**1.00**	141	**141**	102	**102**	39	**39**	42	**42**	300	**300**
E00042554	92	130	**0.71**	127	**90**	80	**57**	47	**33**	40	**28**	246	**174**
E00042555	159	159	**1.00**	161	**161**	118	**118**	43	**43**	61	**61**	319	**319**
E00042570	28	147	**0.19**	143	**27**	110	**21**	33	**6**	49	**9**	300	**57**
E00042571	8	122	**0.07**	115	**8**	95	**6**	20	**1**	47	**3**	163	**11**
E00042572	116	133	**0.87**	129	**113**	91	**79**	38	**33**	39	**34**	265	**231**
E00042573	115	115	**1.00**	101	**101**	80	**80**	21	**21**	35	**35**	168	**168**
E00042574	156	156	**1.00**	152	**152**	110	**110**	42	**42**	52	**52**	276	**276**
E00042575	140	140	**1.00**	139	**139**	111	**111**	28	**28**	37	**37**	271	**271**
E00042740	115	143	**0.80**	134	**108**	116	**93**	18	**14**	51	**41**	285	**229**
E00042741	76	118	**0.64**	113	**73**	80	**52**	33	**21**	31	**20**	293	**189**
E00042742	84	136	**0.62**	129	**80**	106	**65**	23	**14**	33	**20**	289	**179**
E00042745	135	136	**0.99**	125	**124**	95	**94**	30	**30**	109	**108**	280	**278**
E00042746	72	121	**0.60**	116	**69**	76	**45**	40	**24**	37	**22**	253	**151**

E00042748	6	110	**0.05**	110	**6**	73	**4**	37	**2**	43	**2**	202	**11**
E00042752	57	57	**1.00**	57	**57**	45	**45**	12	**12**	15	**15**	104	**104**
E00042753	5	100	**0.05**	99	**5**	88	**4**	11	**1**	9	**0**	118	**6**
E00042754	106	109	**0.97**	104	**101**	93	**90**	11	**11**	38	**37**	187	**182**
E00042755	100	100	**1.00**	94	**94**	83	**83**	11	**11**	13	**13**	122	**122**
E00042763	8	102	**0.08**	133	**10**	108	**8**	25	**2**	47	**4**	242	**19**
E00175582	155	160	**0.97**	155	**150**	117	**113**	38	**37**	60	**58**	303	**294**
Subtotal 40				3393	**2311**	2604	**1789**	789	**522**	1133	**804**	6510	**4490**
Service Area 41													
E00042747	109	136	**0.80**	135	**108**	74	**59**	61	**49**	15	**12**	238	**191**
E00042748	8	110	**0.07**	110	**8**	73	**5**	37	**3**	43	**3**	202	**15**
E00042750	50	104	**0.48**	94	**45**	85	**41**	9	**4**	25	**12**	132	**63**
E00042756	92	127	**0.72**	124	**90**	91	**66**	33	**24**	33	**24**	269	**195**
E00042757	105	105	**1.00**	112	**112**	89	**89**	23	**23**	34	**34**	179	**179**
E00042758	88	127	**0.69**	127	**88**	98	**68**	29	**20**	54	**37**	244	**169**
E00042759	102	102	**1.00**	132	**132**	118	**118**	14	**14**	95	**95**	232	**232**
E00042760	157	157	**1.00**	153	**153**	124	**124**	29	**29**	98	**98**	244	**244**
E00042761	9	132	**0.07**	128	**9**	112	**8**	16	**1**	37	**3**	284	**19**
E00042762	92	128	**0.72**	125	**90**	100	**72**	25	**18**	32	**23**	248	**178**
E00042764	50	134	**0.37**	132	**49**	97	**36**	35	**13**	58	**22**	326	**122**
E00042765	182	182	**1.00**	196	**196**	160	**160**	36	**36**	9	**9**	242	**242**
E00042766	123	123	**1.00**	163	**163**	138	**138**	25	**25**	52	**52**	216	**216**
E00042767	137	137	**1.00**	153	**153**	106	**106**	47	**47**	51	**51**	299	**299**
E00042769	29	128	**0.23**	128	**29**	72	**16**	56	**13**	27	**6**	274	**62**
E00042770	72	122	**0.59**	136	**80**	95	**56**	41	**24**	54	**32**	226	**133**
E00042771	78	141	**0.55**	126	**70**	83	**46**	43	**24**	40	**22**	219	**121**
E00042777	57	126	**0.45**	121	**55**	80	**36**	41	**19**	43	**19**	221	**100**
E00042778	131	131	**1.00**	126	**126**	87	**87**	39	**39**	36	**36**	195	**195**
E00042800	1	121	**0.01**	112	**1**	65	**1**	47	**0**	23	**0**	214	**2**
E00042802	21	131	**0.16**	130	**21**	74	**12**	56	**9**	43	**7**	289	**46**
Subtotal 41				2763	**1778**	2021	**1344**	742	**434**	902	**597**	4993	**3024**
Service Area 42													
E00042557	139	139	**1.00**	132	**132**	79	**79**	53	**53**	25	**25**	281	**281**
E00042558	122	122	**1.00**	110	**110**	71	**71**	39	**39**	19	**19**	181	**181**

E00042559	22	146	**0.15**	139	**21**	110	**17**	29	**4**	30	**5**	324	**49**
E00042772	139	139	**1.00**	131	**131**	64	**64**	67	**67**	36	**36**	298	**298**
E00042773	113	120	**0.94**	118	**111**	82	**77**	36	**34**	57	**54**	175	**165**
E00042776	69	172	**0.40**	167	**67**	92	**37**	75	**30**	36	**14**	352	**141**
E00042781	91	91	**1.00**	119	**119**	82	**82**	37	**37**	46	**46**	187	**187**
E00042782	1	120	**0.01**	115	**1**	57	**0**	58	**0**	30	**0**	277	**2**
E00042784	126	126	**1.00**	123	**123**	90	**90**	33	**33**	52	**52**	167	**167**
E00042786	16	130	**0.12**	124	**15**	61	**8**	63	**8**	29	**4**	316	**39**
E00042789	51	137	**0.37**	136	**51**	81	**30**	55	**20**	44	**16**	264	**98**
E00042792	6	140	**0.04**	131	**6**	99	**4**	32	**1**	38	**2**	253	**11**
E00042794	151	151	**1.00**	143	**143**	77	**77**	66	**66**	43	**43**	323	**323**
E00042795	163	163	**1.00**	144	**144**	87	**87**	57	**57**	47	**47**	311	**311**
Subtotal 42				1832	**1174**	1132	**723**	700	**450**	532	**362**	3709	**2253**
Service Area 43													
E00042184	5	187	**0.03**	192	**5**	95	**3**	97	**3**	73	**2**	356	**10**
E00042188	64	148	**0.43**	134	**58**	73	**32**	61	**26**	36	**16**	304	**131**
E00042194	11	138	**0.08**	138	**11**	84	**7**	54	**4**	54	**4**	282	**22**
E00042195	15	149	**0.10**	144	**14**	85	**9**	59	**6**	43	**4**	308	**31**
E00042402	1	132	**0.01**	128	**1**	57	**0**	71	**1**	31	**0**	198	**2**
E00042403	30	187	**0.16**	180	**29**	91	**15**	89	**14**	62	**10**	338	**54**
E00042404	143	143	**1.00**	141	**141**	58	**58**	83	**83**	60	**60**	292	**292**
E00042405	140	140	**1.00**	130	**130**	42	**42**	88	**88**	25	**25**	243	**243**
E00042406	102	252	**0.40**	210	**85**	65	**26**	145	**59**	14	**6**	564	**228**
E00042407	112	112	**1.00**	110	**110**	42	**42**	68	**68**	45	**45**	253	**253**
E00042408	113	121	**0.93**	119	**111**	50	**47**	69	**64**	33	**31**	340	**318**
E00042409	157	157	**1.00**	147	**147**	51	**51**	96	**96**	27	**27**	245	**245**
E00042410	133	169	**0.79**	161	**127**	53	**42**	108	**85**	12	**9**	294	**231**
E00042411	120	120	**1.00**	114	**114**	52	**52**	62	**62**	3	**3**	247	**247**
E00042412	50	117	**0.43**	120	**51**	57	**24**	63	**27**	7	**3**	349	**149**
E00042413	38	138	**0.28**	129	**36**	68	**19**	61	**17**	13	**4**	350	**96**
E00042416	114	134	**0.85**	123	**105**	70	**60**	53	**45**	33	**28**	200	**170**
E00042417	92	147	**0.63**	135	**84**	89	**56**	46	**29**	52	**33**	195	**122**
E00042418	129	129	**1.00**	124	**124**	47	**47**	77	**77**	16	**16**	287	**287**
E00042419	178	178	**1.00**	175	**175**	57	**57**	118	**118**	24	**24**	381	**381**

E00042420	137	137	**1.00**	136	**136**	59	**59**	77	**77**	44	**44**	224	**224**
E00042421	115	115	**1.00**	104	**104**	39	**39**	65	**65**	22	**22**	196	**196**
E00042422	107	122	**0.88**	121	**106**	36	**32**	85	**75**	38	**33**	318	**279**
E00042423	25	109	**0.23**	109	**25**	41	**9**	68	**16**	34	**8**	290	**67**
E00042424	148	148	**1.00**	139	**139**	44	**44**	95	**95**	19	**19**	291	**291**
E00042425	119	119	**1.00**	113	**113**	41	**41**	72	**72**	30	**30**	298	**298**
E00042426	168	168	**1.00**	136	**136**	52	**52**	84	**84**	12	**12**	314	**314**
E00042427	195	195	**1.00**	176	**176**	72	**72**	104	**104**	16	**16**	372	**372**
E00042428	169	169	**1.00**	160	**160**	62	**62**	98	**98**	8	**8**	336	**336**
E00042429	98	102	**0.96**	94	**90**	38	**37**	56	**54**	15	**14**	308	**296**
E00042430	82	130	**0.63**	120	**76**	39	**25**	81	**51**	20	**13**	224	**141**
E00042431	91	93	**0.98**	91	**89**	43	**42**	48	**47**	16	**16**	233	**228**
E00042432	59	160	**0.37**	145	**53**	70	**26**	75	**28**	20	**7**	342	**126**
E00042433	3	86	**0.03**	81	**3**	34	**1**	47	**2**	12	**0**	225	**8**
Subtotal 43				4579	**3065**	1956	**1227**	2623	**1838**	969	**592**	9997	**6689**
Service Area 44													
E00042179	51	169	**0.30**	160	**48**	58	**18**	102	**31**	37	**11**	223	**67**
E00042190	133	133	**1.00**	131	**131**	58	**58**	73	**73**	58	**58**	297	**297**
E00042197	108	127	**0.85**	107	**91**	64	**54**	43	**37**	45	**38**	221	**188**
E00042199	109	125	**0.87**	123	**107**	63	**55**	60	**52**	44	**38**	244	**213**
E00042200	133	133	**1.00**	125	**125**	80	**80**	45	**45**	47	**47**	237	**237**
E00042203	79	107	**0.74**	105	**78**	77	**57**	28	**21**	34	**25**	203	**150**
E00042205	2	116	**0.02**	118	**2**	62	**1**	56	**1**	47	**1**	262	**5**
E00042206	131	131	**1.00**	125	**125**	68	**68**	57	**57**	27	**27**	242	**242**
E00042214	55	117	**0.47**	113	**53**	62	**29**	51	**24**	47	**22**	235	**110**
E00042215	3	115	**0.03**	113	**3**	46	**1**	67	**2**	33	**1**	271	**7**
E00042216	46	127	**0.36**	116	**42**	49	**18**	67	**24**	34	**12**	233	**84**
E00175589	75	106	**0.71**	104	**74**	63	**45**	41	**29**	34	**24**	466	**330**
E00175590	107	107	**1.00**	98	**98**	33	**33**	65	**65**	22	**22**	184	**184**
Subtotal 44				1538	**977**	783	**516**	755	**460**	509	**327**	3318	**2114**

Appendix E: Output Areas Involved in the Calculation of the Denominator Taking into Consideration Overlays of Service Areas in Newcastle Applying the PWC Method

OA Code	Resident	Deprived Household	Non-Deprived Household	Heavy User Group	Light User Group
E00042042	268	97	14	33	235
E00042043	340	62	81	37	303
E00042044	264	74	43	26	238
E00042045	234	91	27	30	204
E00042046	461	118	43	50	411
E00042047	346	116	38	45	301
E00042048	354	76	70	58	297
E00042048	354	76	70	58	297
E00042049	336	74	69	52	284
E00042050	384	94	48	93	295
E00042051	312	71	57	34	278
E00042052	329	126	58	56	273
E00042053	309	82	33	46	263
E00042054	291	80	58	40	251
E00042054	291	80	58	40	251
E00042055	313	63	76	30	284
E00042056	236	87	26	56	180
E00042056	236	87	26	56	180
E00042057	393	97	25	61	332
E00042057	393	97	25	61	332
E00042058	124	34	14	13	111
E00042058	124	34	14	13	111
E00042059	324	101	34	52	272
E00042061	342	116	23	59	283
E00042062	501	137	41	73	428
E00042064	351	136	35	66	285
E00042064	351	136	35	66	285
E00042065	298	117	26	29	269
E00042066	132	84	14	29	103
E00042067	353	58	71	45	308
E00042068	320	61	59	35	285
E00042068	320	61	59	35	285
E00042069	334	73	65	44	290
E00042069	334	73	65	44	290
E00042070	287	70	42	37	250
E00042071	275	62	60	35	240
E00042071	275	62	60	35	240
E00042072	278	86	31	39	239
E00042072	278	86	31	39	239
E00042073	328	73	41	41	287
E00042073	328	73	41	41	287

E00042074	250	82	28	30	220
E00042075	361	100	34	77	284
E00042076	371	93	36	70	301
E00042077	245	53	58	25	220
E00042078	256	64	66	32	224
E00042079	244	79	37	23	221
E00042080	248	90	32	34	214
E00042081	433	42	97	47	386
E00042082	295	52	72	54	242
E00042082	295	52	72	54	242
E00042083	313	52	73	29	284
E00042083	313	52	73	29	284
E00042084	236	48	72	12	224
E00042084	236	48	72	12	224
E00042085	246	106	27	59	189
E00042086	335	87	40	29	306
E00042087	304	85	27	46	258
E00042087	304	85	27	46	258
E00042087	304	85	27	46	258
E00042088	360	71	71	38	322
E00042088	360	71	71	38	322
E00042089	194	113	8	33	161
E00042089	194	113	8	33	161
E00042089	194	113	8	33	161
E00042090	267	84	38	40	227
E00042090	267	84	38	40	227
E00042091	362	94	34	45	317
E00042092	295	79	58	21	274
E00042093	253	89	28	27	226
E00042094	201	85	24	33	169
E00042095	281	87	35	47	234
E00042096	218	93	22	43	175
E00042097	396	131	54	77	319
E00042099	397	107	31	50	347
E00042100	326	67	48	92	235
E00042100	326	67	48	92	235
E00042101	243	100	17	45	198
E00042101	243	100	17	45	198
E00042102	399	100	39	53	346
E00042103	323	101	30	43	280
E00042104	488	117	58	70	418
E00042104	488	117	58	70	418
E00042106	363	89	29	42	321
E00042107	263	100	25	42	221
E00042107	263	100	25	42	221

E00042107	263	100	25	42	221
E00042108	309	114	27	50	260
E00042108	309	114	27	50	260
E00042108	309	114	27	50	260
E00042109	298	138	29	52	246
E00042110	250	100	34	29	221
E00042111	227	105	31	44	183
E00042111	227	105	31	44	183
E00042111	227	105	31	44	183
E00042112	280	125	30	45	235
E00042112	280	125	30	45	235
E00042112	280	125	30	45	235
E00042113	279	98	24	42	237
E00042114	256	86	68	20	236
E00042114	256	86	68	20	236
E00042115	299	117	21	48	251
E00042115	299	117	21	48	251
E00042116	255	72	45	25	230
E00042117	227	39	87	8	219
E00042118	460	117	25	117	343
E00042120	342	111	41	43	299
E00042121	284	76	58	21	263
E00042122	257	82	45	25	232
E00042123	210	44	61	14	196
E00042124	206	51	84	10	196
E00042125	208	99	32	15	193
E00042125	208	99	32	15	193
E00042125	208	99	32	15	193
E00042126	328	186	45	33	295
E00042126	328	186	45	33	295
E00042126	328	186	45	33	295
E00042127	342	103	44	34	308
E00042127	342	103	44	34	308
E00042127	342	103	44	34	308
E00042128	168	92	33	29	139
E00042128	168	92	33	29	139
E00042128	168	92	33	29	139
E00042129	465	156	44	68	398
E00042129	465	156	44	68	398
E00042129	465	156	44	68	398
E00042130	280	115	20	48	232
E00042131	216	113	27	32	184
E00042131	216	113	27	32	184
E00042131	216	113	27	32	184
E00042132	225	102	32	15	210

E00042132	225	102	32	15	210
E00042132	225	102	32	15	210
E00042133	279	117	40	28	251
E00042133	279	117	40	28	251
E00042134	299	101	39	34	265
E00042134	299	101	39	34	265
E00042134	299	101	39	34	265
E00042135	267	106	20	43	224
E00042136	285	117	33	42	243
E00042136	285	117	33	42	243
E00042136	285	117	33	42	243
E00042137	245	86	38	26	219
E00042138	301	100	24	42	259
E00042139	263	91	22	56	207
E00042140	294	72	53	36	258
E00042140	294	72	53	36	258
E00042141	352	57	76	45	307
E00042141	352	57	76	45	307
E00042142	324	46	76	32	292
E00042143	299	50	74	32	267
E00042144	279	48	72	28	251
E00042145	274	61	57	34	240
E00042145	274	61	57	34	240
E00042146	294	50	74	24	270
E00042147	526	69	135	91	435
E00042148	304	38	85	29	275
E00042149	320	55	71	32	288
E00042149	320	55	71	32	288
E00042150	293	43	77	15	278
E00042150	293	43	77	15	278
E00042151	278	57	59	29	249
E00042151	278	57	59	29	249
E00042152	321	46	67	30	291
E00042153	256	88	38	39	217
E00042154	271	59	75	36	235
E00042155	286	88	28	64	222
E00042156	216	87	37	46	170
E00042157	274	63	61	28	246
E00042158	305	72	58	55	250
E00042159	313	95	44	37	276
E00042160	297	95	33	48	249
E00042161	294	80	54	36	258
E00042162	153	43	22	25	128
E00042164	259	69	50	24	235
E00042165	278	76	37	29	249

E00042166	229	76	32	36	193
E00042168	265	57	68	47	218
E00042169	291	48	70	66	225
E00042170	314	48	73	49	265
E00042171	312	48	75	45	267
E00042172	228	38	70	28	200
E00042173	314	41	76	54	260
E00042174	317	50	72	92	225
E00042175	323	51	73	58	265
E00042176	340	49	80	55	285
E00042177	253	56	65	74	179
E00042178	337	45	90	49	288
E00042178	337	45	90	49	288
E00042179	260	58	102	37	223
E00042180	539	59	133	52	487
E00042182	385	44	92	43	342
E00042183	317	64	53	37	280
E00042184	429	95	97	73	356
E00042185	339	50	79	54	285
E00042186	189	27	86	8	181
E00042187	586	101	119	75	511
E00042188	340	73	61	36	304
E00042189	268	50	64	60	209
E00042190	355	58	73	58	297
E00042191	256	49	60	38	218
E00042192	226	36	42	17	209
E00042193	317	78	43	45	272
E00042194	336	84	54	54	282
E00042195	351	85	59	43	308
E00042196	311	49	92	36	275
E00042197	266	64	43	45	221
E00042198	257	62	63	52	205
E00042199	288	63	60	44	244
E00042200	284	80	45	47	237
E00042201	299	43	75	39	260
E00042202	331	49	79	42	289
E00042203	237	77	28	34	203
E00042205	309	62	56	47	262
E00042206	269	68	57	27	242
E00042207	330	42	91	39	291
E00042208	234	55	43	38	196
E00042209	275	47	71	63	213
E00042210	292	50	58	47	245
E00042211	271	34	73	52	219
E00042212	307	55	59	34	273

E00042213	452	31	115	42	410
E00042214	282	62	51	47	235
E00042215	304	46	67	33	271
E00042216	267	49	67	34	233
E00042217	326	58	61	58	268
E00042218	301	65	50	54	247
E00042219	328	57	70	41	287
E00042220	353	37	94	24	329
E00042221	200	52	67	29	171
E00042222	303	83	43	40	263
E00042223	297	53	66	43	254
E00042224	292	37	81	24	268
E00042225	291	57	65	55	236
E00042226	157	107	12	59	98
E00042227	255	74	45	26	229
E00042228	424	147	46	120	304
E00042228	424	147	46	120	304
E00042229	262	62	61	36	226
E00042229	262	62	61	36	226
E00042229	262	62	61	36	226
E00042230	324	106	22	44	280
E00042232	325	50	65	37	288
E00042233	304	88	45	47	257
E00042234	340	59	58	75	265
E00042235	290	67	50	36	254
E00042236	227	73	39	49	178
E00042236	227	73	39	49	178
E00042237	119	33	11	19	100
E00042238	366	90	34	52	314
E00042240	287	101	29	49	238
E00042241	252	95	28	58	194
E00042242	276	89	36	43	234
E00042243	257	72	40	32	225
E00042244	329	75	54	52	277
E00042245	451	117	78	79	372
E00042246	235	69	28	36	199
E00042247	162	113	9	82	80
E00042248	272	56	64	46	226
E00042248	272	56	64	46	226
E00042249	250	66	50	51	200
E00042249	250	66	50	51	200
E00042250	258	61	50	46	212
E00042250	258	61	50	46	212
E00042251	365	85	39	55	310
E00042252	221	110	19	66	155

E00042253	260	67	50	60	200
E00042253	260	67	50	60	200
E00042254	282	79	54	31	251
E00042255	326	92	41	49	277
E00042255	326	92	41	49	277
E00042256	323	102	38	52	271
E00042257	267	70	46	59	208
E00042257	267	70	46	59	208
E00042258	289	100	32	27	262
E00042259	294	55	56	51	243
E00042259	294	55	56	51	243
E00042260	386	94	36	42	344
E00042261	280	108	37	53	227
E00042262	534	123	51	64	470
E00042262	534	123	51	64	470
E00042262	534	123	51	64	470
E00042263	340	94	58	44	296
E00042263	340	94	58	44	296
E00042264	288	85	47	51	237
E00042264	288	85	47	51	237
E00042265	366	95	45	56	310
E00042265	366	95	45	56	310
E00042265	366	95	45	56	310
E00042266	512	122	51	78	434
E00042266	512	122	51	78	434
E00042267	401	80	43	56	345
E00042267	401	80	43	56	345
E00042268	243	78	33	33	210
E00042269	405	123	35	63	342
E00042269	405	123	35	63	342
E00042270	400	91	46	52	348
E00042270	400	91	46	52	348
E00042270	400	91	46	52	348
E00042271	445	74	57	61	384
E00042271	445	74	57	61	384
E00042272	608	104	53	95	514
E00042272	608	104	53	95	514
E00042273	463	91	37	59	404
E00042273	463	91	37	59	404
E00042274	291	90	35	45	246
E00042274	291	90	35	45	246
E00042275	468	83	45	65	403
E00042275	468	83	45	65	403
E00042275	468	83	45	65	403
E00042276	372	83	31	52	320

E00042276	372	83	31	52	320
E00042277	413	87	32	28	385
E00042277	413	87	32	28	385
E00042277	413	87	32	28	385
E00042278	256	104	11	42	214
E00042278	256	104	11	42	214
E00042279	394	85	27	90	304
E00042279	394	85	27	90	304
E00042280	494	135	42	62	432
E00042280	494	135	42	62	432
E00042280	494	135	42	62	432
E00042281	353	79	54	57	296
E00042281	353	79	54	57	296
E00042281	353	79	54	57	296
E00042281	353	79	54	57	296
E00042282	310	69	37	40	270
E00042282	310	69	37	40	270
E00042282	310	69	37	40	270
E00042283	182	139	6	51	131
E00042284	489	118	26	59	430
E00042284	489	118	26	59	430
E00042284	489	118	26	59	430
E00042285	404	103	33	55	349
E00042285	404	103	33	55	349
E00042286	394	106	56	66	328
E00042286	394	106	56	66	328
E00042287	298	91	19	32	266
E00042287	298	91	19	32	266
E00042288	304	107	39	39	265
E00042289	263	101	31	57	206
E00042290	265	100	41	43	222
E00042291	260	80	45	35	225
E00042292	226	52	73	32	194
E00042293	290	64	67	41	251
E00042294	278	81	52	40	238
E00042295	369	107	27	29	340
E00042295	369	107	27	29	340
E00042296	256	115	31	41	215
E00042296	256	115	31	41	215
E00042297	289	72	58	38	251
E00042298	235	65	32	72	163
E00042299	340	97	40	30	310
E00042299	340	97	40	30	310
E00042300	277	90	31	31	246
E00042300	277	90	31	31	246

E00042301	334	93	34	45	289
E00042301	334	93	34	45	289
E00042302	312	79	42	35	277
E00042302	312	79	42	35	277
E00042303	225	99	38	43	182
E00042303	225	99	38	43	182
E00042304	297	103	40	40	257
E00042304	297	103	40	40	257
E00042305	327	112	33	45	282
E00042306	246	88	46	37	209
E00042306	246	88	46	37	209
E00042307	265	70	25	38	227
E00042307	265	70	25	38	227
E00042308	336	94	23	42	294
E00042308	336	94	23	42	294
E00042309	246	64	50	53	193
E00042310	171	76	40	47	124
E00042311	216	87	32	42	174
E00042312	262	83	41	49	213
E00042313	301	78	35	37	264
E00042314	267	76	48	44	223
E00042315	267	77	40	42	226
E00042316	343	92	39	48	295
E00042317	377	94	41	52	325
E00042318	405	103	29	40	365
E00042319	301	69	50	45	256
E00042320	263	60	56	39	224
E00042321	157	63	19	58	100
E00042322	256	87	35	49	207
E00042323	316	80	61	45	271
E00042324	333	98	60	52	281
E00042324	333	98	60	52	281
E00042325	257	74	45	42	215
E00042326	358	77	53	53	305
E00042327	270	86	44	38	232
E00042328	369	86	51	58	311
E00042329	196	103	31	21	175
E00042330	207	92	28	39	168
E00042331	201	79	24	41	160
E00042332	533	88	120	62	471
E00042333	289	84	36	45	244
E00042334	281	108	32	46	235
E00042335	319	100	42	44	275
E00042336	255	116	39	75	180
E00042337	310	93	46	60	250

E00042338	394	109	51	64	330
E00042338	394	109	51	64	330
E00042339	318	112	34	50	268
E00042340	276	78	33	30	246
E00042341	268	55	53	38	230
E00042342	284	69	44	39	245
E00042343	297	85	46	52	245
E00042344	202	51	51	20	182
E00042345	294	65	41	49	245
E00042345	294	65	41	49	245
E00042347	312	104	47	42	270
E00042347	312	104	47	42	270
E00042348	309	70	25	40	269
E00042348	309	70	25	40	269
E00042349	389	70	62	55	334
E00042350	407	74	59	66	342
E00042350	407	74	59	66	342
E00042351	281	65	31	42	239
E00042351	281	65	31	42	239
E00042352	293	87	22	47	246
E00042353	268	71	47	44	224
E00042354	325	74	40	43	282
E00042354	325	74	40	43	282
E00042355	355	74	48	48	307
E00042356	414	70	52	45	369
E00042356	414	70	52	45	369
E00042357	471	80	44	77	394
E00042357	471	80	44	77	394
E00042358	132	39	16	19	113
E00042359	165	63	12	34	131
E00042360	315	86	55	48	267
E00042361	249	62	56	38	211
E00042361	249	62	56	38	211
E00042362	225	104	35	42	183
E00042363	294	53	64	49	245
E00042364	266	72	60	66	200
E00042365	249	73	56	48	202
E00042366	253	77	47	27	226
E00042367	222	87	36	32	190
E00042368	328	67	58	57	271
E00042369	220	84	27	37	183
E00042370	266	115	40	101	166
E00042370	266	115	40	101	166
E00042370	266	115	40	101	166
E00042371	306	55	94	40	266

E00042371	306	55	94	40	266
E00042372	259	88	37	42	217
E00042372	259	88	37	42	217
E00042373	360	35	91	43	317
E00042373	360	35	91	43	317
E00042374	310	27	97	30	280
E00042374	310	27	97	30	280
E00042375	277	68	69	46	231
E00042375	277	68	69	46	231
E00042375	277	68	69	46	231
E00042376	240	52	50	23	217
E00042377	270	88	35	52	218
E00042378	353	39	95	41	312
E00042378	353	39	95	41	312
E00042378	353	39	95	41	312
E00042378	353	39	95	41	312
E00042379	352	52	118	29	323
E00042379	352	52	118	29	323
E00042379	352	52	118	29	323
E00042380	417	74	99	53	364
E00042381	279	41	80	33	246
E00042381	279	41	80	33	246
E00042381	279	41	80	33	246
E00042382	247	83	64	50	197
E00042383	489	44	94	39	450
E00042383	489	44	94	39	450
E00042384	392	54	83	42	350
E00042385	349	44	86	38	311
E00042386	313	43	76	30	283
E00042387	232	43	65	37	195
E00042387	232	43	65	37	195
E00042388	449	97	118	91	358
E00042389	274	30	66	31	243
E00042390	164	70	27	37	127
E00042391	279	43	58	35	244
E00042392	196	77	38	25	171
E00042393	294	85	35	29	265
E00042394	330	58	60	42	288
E00042395	200	69	35	37	163
E00042395	200	69	35	37	163
E00042396	203	88	43	40	163
E00042396	203	88	43	40	163
E00042397	440	65	151	53	387
E00042397	440	65	151	53	387
E00042397	440	65	151	53	387

E00042398	253	63	49	60	193
E00042399	313	63	66	43	270
E00042400	353	69	53	87	266
E00042400	353	69	53	87	266
E00042400	353	69	53	87	266
E00042401	305	46	76	47	258
E00042402	229	57	71	31	198
E00042403	400	91	89	62	338
E00042404	352	58	83	60	292
E00042405	268	42	88	25	243
E00042406	578	65	145	14	564
E00042407	298	42	68	45	253
E00042408	373	50	69	33	340
E00042409	272	51	96	27	245
E00042410	306	53	108	12	294
E00042411	250	52	62	3	247
E00042412	356	57	63	7	349
E00042412	356	57	63	7	349
E00042413	363	68	61	13	350
E00042413	363	68	61	13	350
E00042414	232	38	60	10	222
E00042415	328	79	74	17	311
E00042416	233	70	53	33	200
E00042417	247	89	46	52	195
E00042418	303	47	77	16	287
E00042419	405	57	118	24	381
E00042420	268	59	77	44	224
E00042421	218	39	65	22	196
E00042422	356	36	85	38	318
E00042423	324	41	68	34	290
E00042424	310	44	95	19	291
E00042425	328	41	72	30	298
E00042426	326	52	84	12	314
E00042427	388	72	104	16	372
E00042428	344	62	98	8	336
E00042429	323	38	56	15	308
E00042430	244	39	81	20	224
E00042431	249	43	48	16	233
E00042432	362	70	75	20	342
E00042433	237	34	47	12	225
E00042433	237	34	47	12	225
E00042434	259	67	66	24	235
E00042435	354	69	64	18	336
E00042435	354	69	64	18	336
E00042435	354	69	64	18	336

E00042436	232	49	61	10	222
E00042437	317	69	62	26	291
E00042437	317	69	62	26	291
E00042437	317	69	62	26	291
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042439	598	86	111	9	589
E00042439	598	86	111	9	589
E00042439	598	86	111	9	589
E00042440	355	46	80	24	331
E00042440	355	46	80	24	331
E00042441	429	75	101	18	411
E00042441	429	75	101	18	411
E00042442	524	46	110	11	513
E00042442	524	46	110	11	513
E00042443	424	64	119	8	416
E00042443	424	64	119	8	416
E00042444	432	54	101	10	422
E00042444	432	54	101	10	422
E00042445	220	43	64	54	166
E00042445	220	43	64	54	166
E00042445	220	43	64	54	166
E00042446	352	44	78	11	341
E00042447	385	53	80	6	379
E00042447	385	53	80	6	379
E00042447	385	53	80	6	379
E00042448	542	33	109	9	533
E00042448	542	33	109	9	533
E00042448	542	33	109	9	533
E00042449	321	24	82	16	305
E00042450	609	50	133	7	602
E00042450	609	50	133	7	602
E00042451	379	74	91	15	364
E00042451	379	74	91	15	364
E00042451	379	74	91	15	364
E00042452	513	53	104	9	504
E00042452	513	53	104	9	504
E00042453	286	71	57	26	260
E00042453	286	71	57	26	260
E00042453	286	71	57	26	260
E00042454	340	40	85	8	332
E00042454	340	40	85	8	332
E00042455	430	44	87	43	387
E00042455	430	44	87	43	387

E00042456	295	44	65	34	261
E00042456	295	44	65	34	261
E00042456	295	44	65	34	261
E00042457	616	51	94	4	612
E00042457	616	51	94	4	612
E00042458	435	63	104	18	417
E00042458	435	63	104	18	417
E00042458	435	63	104	18	417
E00042459	475	42	89	15	460
E00042459	475	42	89	15	460
E00042460	414	42	81	12	402
E00042460	414	42	81	12	402
E00042461	384	34	92	26	358
E00042461	384	34	92	26	358
E00042462	448	54	90	25	423
E00042462	448	54	90	25	423
E00042463	390	55	94	17	373
E00042463	390	55	94	17	373
E00042464	317	56	105	31	286
E00042464	317	56	105	31	286
E00042465	436	50	71	1	435
E00042465	436	50	71	1	435
E00042466	301	45	74	91	210
E00042466	301	45	74	91	210
E00042467	345	47	118	10	335
E00042467	345	47	118	10	335
E00042467	345	47	118	10	335
E00042468	448	93	134	39	409
E00042468	448	93	134	39	409
E00042469	226	81	51	38	188
E00042469	226	81	51	38	188
E00042470	370	33	100	33	338
E00042470	370	33	100	33	338
E00042471	326	54	81	33	293
E00042471	326	54	81	33	293
E00042471	326	54	81	33	293
E00042472	189	58	53	50	139
E00042472	189	58	53	50	139
E00042473	349	31	85	34	315
E00042474	237	41	64	38	199
E00042474	237	41	64	38	199
E00042475	338	27	74	3	335
E00042476	512	46	99	8	504
E00042477	460	47	100	10	450
E00042478	367	108	38	37	330

E00042478	367	108	38	37	330
E00042479	311	116	19	64	247
E00042479	311	116	19	64	247
E00042480	321	59	65	41	280
E00042480	321	59	65	41	280
E00042481	363	71	41	40	323
E00042481	363	71	41	40	323
E00042482	300	77	57	47	253
E00042483	310	42	73	37	273
E00042484	271	52	62	29	242
E00042485	302	77	49	48	254
E00042485	302	77	49	48	254
E00042486	222	85	26	41	181
E00042487	351	69	58	51	300
E00042488	254	71	44	39	215
E00042489	295	46	66	36	259
E00042490	326	79	55	44	282
E00042491	507	112	114	99	410
E00042492	328	71	56	42	286
E00042493	249	69	47	40	209
E00042494	282	69	36	31	251
E00042495	193	88	42	16	177
E00042496	335	46	92	69	266
E00042498	299	63	63	50	249
E00042499	333	68	55	49	284
E00042500	401	59	76	76	325
E00042501	218	54	50	45	173
E00042502	388	44	91	45	343
E00042503	367	85	33	42	325
E00042503	367	85	33	42	325
E00042504	228	89	36	35	193
E00042505	260	65	44	32	228
E00042505	260	65	44	32	228
E00042506	167	104	16	44	123
E00042507	467	148	31	64	403
E00042507	467	148	31	64	403
E00042508	195	94	41	36	159
E00042509	362	104	40	66	296
E00042509	362	104	40	66	296
E00042510	294	94	29	38	256
E00042510	294	94	29	38	256
E00042511	293	62	60	46	248
E00042512	310	44	74	42	268
E00042513	301	81	43	49	252
E00042514	311	56	63	30	281

E00042515	258	65	51	23	235
E00042516	363	92	32	37	326
E00042517	240	74	55	26	214
E00042518	250	78	32	38	212
E00042519	318	62	58	25	293
E00042520	265	59	52	44	221
E00042521	319	86	37	64	255
E00042522	325	59	92	45	280
E00042523	331	93	42	43	288
E00042524	288	99	30	47	241
E00042525	369	117	23	86	283
E00042526	324	88	42	42	282
E00042527	234	64	61	27	207
E00042528	317	88	39	37	280
E00042529	237	53	53	38	199
E00042530	289	76	50	26	263
E00042531	260	85	42	52	208
E00042532	293	75	52	41	252
E00042533	269	77	58	23	246
E00042534	247	84	32	46	201
E00042535	266	58	57	16	250
E00042536	287	76	56	41	246
E00042537	306	100	47	58	249
E00042538	287	74	65	41	246
E00042539	256	58	53	33	223
E00042540	262	86	44	52	210
E00042541	278	67	45	39	239
E00042542	273	66	58	19	254
E00042543	266	69	59	34	232
E00042544	285	84	40	52	233
E00042545	288	86	31	54	234
E00042546	272	52	67	16	256
E00042547	394	167	45	57	337
E00042548	270	86	26	39	231
E00042549	386	109	43	52	334
E00042550	318	115	27	36	282
E00042551	296	108	20	43	253
E00042552	170	102	13	46	124
E00042553	342	102	39	42	300
E00042554	286	80	47	40	246
E00042555	380	118	43	61	319
E00042556	238	92	43	32	206
E00042557	306	79	53	25	281
E00042558	200	71	39	19	181
E00042559	354	110	29	30	324

E00042560	325	104	29	31	294
E00042561	254	95	29	25	229
E00042562	290	99	23	30	260
E00042563	281	93	17	33	248
E00042564	307	85	26	34	273
E00042565	199	95	29	19	180
E00042566	327	108	38	48	279
E00042567	282	93	21	38	244
E00042568	246	92	20	35	211
E00042569	215	89	22	54	161
E00042570	349	110	33	49	300
E00042571	210	95	20	47	163
E00042572	304	91	38	39	265
E00042573	203	80	21	35	168
E00042574	328	110	42	52	276
E00042575	308	111	28	37	271
E00042576	376	89	39	39	337
E00042577	274	110	35	37	237
E00042578	313	82	34	45	268
E00042578	313	82	34	45	268
E00042578	313	82	34	45	268
E00042579	196	117	35	9	187
E00042579	196	117	35	9	187
E00042580	447	98	86	5	442
E00042580	447	98	86	5	442
E00042581	261	107	19	56	205
E00042582	263	94	24	37	226
E00042582	263	94	24	37	226
E00042583	174	35	25	5	169
E00042583	174	35	25	5	169
E00042584	241	126	22	62	179
E00042585	245	80	16	36	209
E00042586	438	126	33	61	377
E00042587	295	100	27	38	257
E00042587	295	100	27	38	257
E00042588	370	94	36	45	325
E00042588	370	94	36	45	325
E00042588	370	94	36	45	325
E00042589	305	114	34	33	272
E00042590	271	112	31	52	219
E00042591	247	95	29	26	221
E00042592	151	106	18	11	140
E00042593	319	215	32	27	292
E00042594	208	45	57	7	201
E00042595	171	117	4	92	79

E00042596	179	113	19	38	141
E00042597	200	43	64	11	189
E00042598	315	71	80	16	299
E00042599	196	62	43	12	184
E00042600	338	74	67	24	314
E00042601	132	76	24	9	123
E00042604	545	52	59	7	538
E00042605	498	57	59	2	496
E00042606	406	91	56	39	367
E00042607	383	91	50	47	336
E00042608	443	100	44	66	377
E00042608	443	100	44	66	377
E00042609	496	65	84	24	472
E00042609	496	65	84	24	472
E00042610	292	89	42	53	239
E00042611	344	84	83	41	303
E00042612	198	104	19	57	141
E00042613	329	95	43	48	281
E00042614	284	87	43	47	237
E00042615	286	71	56	42	244
E00042616	266	86	35	37	229
E00042617	318	63	69	41	277
E00042618	220	70	48	44	176
E00042619	277	62	56	58	220
E00042620	258	74	46	37	221
E00042621	255	90	27	37	218
E00042622	297	71	59	60	237
E00042623	300	91	30	36	264
E00042624	339	81	56	46	293
E00042625	286	76	47	42	244
E00042626	358	70	78	47	311
E00042627	254	83	33	55	199
E00042627	254	83	33	55	199
E00042628	386	97	35	86	300
E00042628	386	97	35	86	300
E00042629	287	113	29	64	223
E00042630	152	63	16	22	130
E00042631	198	85	34	21	177
E00042632	263	97	32	48	215
E00042633	290	96	39	49	241
E00042634	319	78	43	41	278
E00042635	219	72	39	23	196
E00042635	219	72	39	23	196
E00042636	274	86	57	41	233
E00042637	534	128	112	76	458

E00042638	251	86	43	21	230
E00042639	250	58	59	26	224
E00042640	244	55	70	20	224
E00042641	357	39	99	14	343
E00042642	413	90	84	24	389
E00042643	441	76	75	28	413
E00042643	441	76	75	28	413
E00042643	441	76	75	28	413
E00042644	333	48	72	13	320
E00042645	443	73	99	8	435
E00042646	255	99	23	25	230
E00042647	218	49	46	15	203
E00042647	218	49	46	15	203
E00042647	218	49	46	15	203
E00042648	305	88	72	62	243
E00042649	294	51	64	10	284
E00042650	356	60	88	27	329
E00042651	329	52	73	13	316
E00042652	218	44	72	17	201
E00042652	218	44	72	17	201
E00042652	218	44	72	17	201
E00042653	467	61	103	2	465
E00042654	187	117	23	52	135
E00042655	247	45	50	6	241
E00042656	358	52	84	31	327
E00042656	358	52	84	31	327
E00042656	358	52	84	31	327
E00042657	408	52	89	26	382
E00042657	408	52	89	26	382
E00042657	408	52	89	26	382
E00042658	371	61	62	18	353
E00042658	371	61	62	18	353
E00042658	371	61	62	18	353
E00042659	373	45	81	24	349
E00042659	373	45	81	24	349
E00042659	373	45	81	24	349
E00042661	110	74	16	10	100
E00042662	300	53	65	12	288
E00042662	300	53	65	12	288
E00042663	232	46	46	13	219
E00042663	232	46	46	13	219
E00042663	232	46	46	13	219
E00042664	269	80	47	20	249
E00042664	269	80	47	20	249
E00042664	269	80	47	20	249

E00042665	152	115	14	30	122
E00042666	334	91	56	16	318
E00042666	334	91	56	16	318
E00042666	334	91	56	16	318
E00042667	198	31	49	6	192
E00042667	198	31	49	6	192
E00042667	198	31	49	6	192
E00042668	281	63	59	10	271
E00042668	281	63	59	10	271
E00042668	281	63	59	10	271
E00042669	261	35	14	9	252
E00042670	369	111	35	40	329
E00042670	369	111	35	40	329
E00042671	126	63	25	16	110
E00042671	126	63	25	16	110
E00042672	1161	71	19	13	1148
E00042672	1161	71	19	13	1148
E00042673	340	117	56	25	315
E00042673	340	117	56	25	315
E00042674	247	128	40	52	195
E00042677	244	115	43	29	215
E00042679	590	71	37	1	589
E00042681	365	54	85	18	347
E00042682	408	55	90	17	391
E00042683	275	38	98	7	268
E00042685	120	41	13	20	100
E00042686	286	73	48	43	243
E00042686	286	73	48	43	243
E00042687	306	75	47	40	266
E00042687	306	75	47	40	266
E00042688	246	65	49	24	222
E00042688	246	65	49	24	222
E00042689	341	89	45	40	301
E00042689	341	89	45	40	301
E00042690	302	95	34	45	257
E00042691	205	76	9	33	172
E00042691	205	76	9	33	172
E00042691	205	76	9	33	172
E00042693	336	122	23	52	284
E00042693	336	122	23	52	284
E00042694	225	72	13	43	182
E00042694	225	72	13	43	182
E00042695	189	130	3	84	105
E00042697	337	131	26	75	262
E00042697	337	131	26	75	262

E00042702	269	79	40	23	246
E00042702	269	79	40	23	246
E00042703	250	67	53	31	219
E00042703	250	67	53	31	219
E00042704	319	64	61	34	285
E00042704	319	64	61	34	285
E00042705	260	65	56	32	228
E00042705	260	65	56	32	228
E00042706	373	42	99	55	318
E00042706	373	42	99	55	318
E00042706	373	42	99	55	318
E00042706	373	42	99	55	318
E00042707	415	32	121	65	351
E00042707	415	32	121	65	351
E00042707	415	32	121	65	351
E00042707	415	32	121	65	351
E00042708	292	29	87	24	268
E00042708	292	29	87	24	268
E00042708	292	29	87	24	268
E00042709	332	58	74	44	288
E00042710	324	55	90	43	281
E00042710	324	55	90	43	281
E00042710	324	55	90	43	281
E00042711	236	28	90	24	212
E00042711	236	28	90	24	212
E00042711	236	28	90	24	212
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042714	266	43	81	52	214
E00042714	266	43	81	52	214
E00042715	292	43	84	43	249
E00042716	288	53	76	33	255
E00042717	544	85	148	43	501
E00042717	544	85	148	43	501
E00042717	544	85	148	43	501
E00042718	260	48	82	29	231
E00042718	260	48	82	29	231
E00042719	310	43	89	45	265
E00042720	277	39	76	36	241
E00042721	376	48	82	69	307

E00042722	299	41	101	26	273
E00042723	360	54	77	55	305
E00042723	360	54	77	55	305
E00042724	369	41	110	54	315
E00042725	385	49	99	83	305
E00042725	385	49	99	83	305
E00042725	385	49	99	83	305
E00042726	324	33	113	24	300
E00042726	324	33	113	24	300
E00042726	324	33	113	24	300
E00042727	354	37	102	17	337
E00042727	354	37	102	17	337
E00042727	354	37	102	17	337
E00042728	354	33	91	42	312
E00042728	354	33	91	42	312
E00042729	314	27	89	35	279
E00042729	314	27	89	35	279
E00042730	338	76	69	79	259
E00042730	338	76	69	79	259
E00042730	338	76	69	79	259
E00042731	336	36	94	42	294
E00042731	336	36	94	42	294
E00042732	244	43	86	29	215
E00042733	450	62	50	65	385
E00042734	245	58	67	34	211
E00042735	250	27	86	25	225
E00042735	250	27	86	25	225
E00042735	250	27	86	25	225
E00042735	250	27	86	25	225
E00042736	325	32	95	35	290
E00042737	270	42	93	32	239
E00042738	246	33	96	19	227
E00042739	319	25	87	38	281
E00042739	319	25	87	38	281
E00042739	319	25	87	38	281
E00042739	319	25	87	38	281
E00042740	336	116	18	51	285
E00042741	324	80	33	31	293
E00042742	322	106	23	33	289
E00042743	311	144	30	30	281
E00042745	388	95	30	109	280
E00042746	290	76	40	37	253
E00042747	253	74	61	15	238
E00042748	245	73	37	43	202
E00042748	245	73	37	43	202

E00042750	157	85	9	25	132
E00042751	117	83	14	18	99
E00042752	119	45	12	15	104
E00042753	127	88	11	9	118
E00042754	225	93	11	38	187
E00042755	135	83	11	13	122
E00042756	302	91	33	33	269
E00042757	213	89	23	34	179
E00042758	298	98	29	54	244
E00042759	327	118	14	95	232
E00042760	341	124	29	98	244
E00042761	321	112	16	37	284
E00042762	280	100	25	32	248
E00042763	289	108	25	47	242
E00042764	384	97	35	58	326
E00042765	251	160	36	9	242
E00042766	268	138	25	52	216
E00042767	350	106	47	51	299
E00042768	241	79	41	30	211
E00042769	301	72	56	27	274
E00042770	280	95	41	54	226
E00042771	259	83	43	40	219
E00042772	334	64	67	36	298
E00042773	232	82	36	57	175
E00042774	217	86	20	33	184
E00042775	356	78	66	47	309
E00042776	388	92	75	36	352
E00042777	264	80	41	43	221
E00042778	231	87	39	36	195
E00042779	244	84	18	22	222
E00042780	298	71	44	39	259
E00042781	232	82	37	46	187
E00042782	307	57	58	30	277
E00042783	297	109	33	71	226
E00042784	219	90	33	52	167
E00042785	231	72	35	28	203
E00042786	344	61	63	29	316
E00042787	322	184	49	36	286
E00042788	266	144	27	32	234
E00042789	308	81	55	44	264
E00042790	243	117	15	63	180
E00042791	300	90	22	59	241
E00042792	291	99	32	38	253
E00042793	302	68	33	30	272
E00042794	366	77	66	43	323

E00042795	358	87	57	47	311
E00042796	279	69	51	28	251
E00042797	186	89	25	41	145
E00042798	305	87	25	34	271
E00042799	219	80	39	20	199
E00042800	237	65	47	23	214
E00042801	296	89	37	44	252
E00042802	332	74	56	43	289
E00042803	391	137	24	50	341
E00042805	222	126	9	34	188
E00042805	222	126	9	34	188
E00042806	293	86	32	38	255
E00042807	195	121	22	17	178
E00042808	275	92	27	48	227
E00042808	275	92	27	48	227
E00042810	316	100	17	36	280
E00042811	391	110	14	32	359
E00042811	391	110	14	32	359
E00042812	178	136	12	32	146
E00042812	178	136	12	32	146
E00042814	256	100	20	54	202
E00042816	128	41	13	13	115
E00042818	191	130	24	12	179
E00042819	171	104	34	2	169
E00042820	193	47	29	21	172
E00042822	291	95	56	2	289
E00042823	285	118	21	36	249
E00042823	285	118	21	36	249
E00042823	285	118	21	36	249
E00042824	314	127	15	55	259
E00042824	314	127	15	55	259
E00042824	314	127	15	55	259
E00042825	363	104	74	11	352
E00042826	400	148	94	7	393
E00042827	401	110	26	50	352
E00042827	401	110	26	50	352
E00042828	313	79	56	30	283
E00042829	316	145	85	9	307
E00042830	198	135	21	11	187
E00042831	357	96	38	93	264
E00042832	268	91	33	62	206
E00042833	331	94	48	40	291
E00042833	331	94	48	40	291
E00042834	295	47	65	22	273
E00042834	295	47	65	22	273

E00042835	263	68	54	50	213
E00042835	263	68	54	50	213
E00042836	309	69	49	43	266
E00042837	282	56	69	42	240
E00042837	282	56	69	42	240
E00042838	341	59	77	50	291
E00042839	248	78	42	56	192
E00042839	248	78	42	56	192
E00042840	224	99	22	51	173
E00042841	228	77	36	33	195
E00042842	268	64	55	44	224
E00042842	268	64	55	44	224
E00042843	312	100	45	67	245
E00042844	297	70	59	37	260
E00042845	245	65	52	58	187
E00042845	245	65	52	58	187
E00042846	259	87	45	60	199
E00042846	259	87	45	60	199
E00042847	296	65	59	50	246
E00042847	296	65	59	50	246
E00042848	342	91	51	61	281
E00042849	295	87	45	61	234
E00042850	256	96	34	39	217
E00042851	295	79	50	37	258
E00042852	353	47	86	30	323
E00042853	251	80	43	56	195
E00042854	247	74	43	53	194
E00042854	247	74	43	53	194
E00042855	258	66	55	43	215
E00042855	258	66	55	43	215
E00042856	271	67	55	45	226
E00042856	271	67	55	45	226
E00042857	343	79	61	34	309
E00042858	288	66	59	48	240
E00042858	288	66	59	48	240
E00042859	340	53	80	30	310
E00042859	340	53	80	30	310
E00042859	340	53	80	30	310
E00042860	268	81	46	62	206
E00042861	262	87	47	48	214
E00042862	248	80	43	58	190
E00042862	248	80	43	58	190
E00042863	314	83	51	49	265
E00042864	301	66	66	35	266
E00042865	327	74	67	33	294

E00042866	293	64	68	55	238
E00042867	317	50	71	30	287
E00042868	272	36	67	23	249
E00042869	319	55	80	37	282
E00042870	302	53	76	33	269
E00042871	282	68	60	36	246
E00042871	282	68	60	36	246
E00042872	280	53	75	31	249
E00042873	325	75	62	26	299
E00042873	325	75	62	26	299
E00042874	557	91	75	34	523
E00042874	557	91	75	34	523
E00042875	359	79	46	39	321
E00042875	359	79	46	39	321
E00042876	405	68	58	49	356
E00042876	405	68	58	49	356
E00042877	486	81	60	47	439
E00042877	486	81	60	47	439
E00042877	486	81	60	47	439
E00042878	487	74	55	88	399
E00042878	487	74	55	88	399
E00042879	430	85	37	52	378
E00042879	430	85	37	52	378
E00042880	352	55	59	40	312
E00042881	278	66	62	27	251
E00042881	278	66	62	27	251
E00042882	388	99	36	51	337
E00042882	388	99	36	51	337
E00042883	353	96	58	48	305
E00042883	353	96	58	48	305
E00042884	243	68	61	35	209
E00042884	243	68	61	35	209
E00042885	289	82	51	40	249
E00042885	289	82	51	40	249
E00042886	280	75	85	44	236
E00042886	280	75	85	44	236
E00042887	345	85	50	58	288
E00042888	339	97	48	50	289
E00042888	339	97	48	50	289
E00042889	405	81	63	64	342
E00042890	406	116	43	70	336
E00042891	266	31	82	35	231
E00042892	347	98	37	62	285
E00042893	313	57	59	43	270
E00042893	313	57	59	43	270

E00042894	359	68	44	54	306
E00042895	291	50	63	42	249
E00042896	308	43	68	31	277
E00042897	398	52	65	106	292
E00042897	398	52	65	106	292
E00042898	357	71	55	42	315
E00042899	493	79	68	42	451
E00042899	493	79	68	42	451
E00042899	493	79	68	42	451
E00042900	509	61	77	33	476
E00042900	509	61	77	33	476
E00042901	360	56	54	24	336
E00042902	372	73	50	62	310
E00042902	372	73	50	62	310
E00042903	374	87	50	48	326
E00042903	374	87	50	48	326
E00042904	319	101	22	50	269
E00042905	200	93	26	25	175
E00042906	272	105	25	51	221
E00042907	311	114	40	59	252
E00042907	311	114	40	59	252
E00042908	308	96	45	36	272
E00042908	308	96	45	36	272
E00042909	264	112	46	51	213
E00042909	264	112	46	51	213
E00042910	293	62	70	56	237
E00042911	334	70	61	71	263
E00042912	495	66	113	72	423
E00042913	281	80	55	52	229
E00042914	280	88	27	49	231
E00042915	321	84	37	40	281
E00042916	386	88	25	100	287
E00042917	294	96	30	29	265
E00042918	362	95	32	42	320
E00042919	359	95	42	53	306
E00042920	374	88	30	71	303
E00042921	336	102	23	52	284
E00042922	293	91	25	51	242
E00042923	288	65	61	33	255
E00042924	259	82	29	48	211
E00042925	251	101	20	60	191
E00042926	303	90	26	63	240
E00042927	268	102	18	41	227
E00042928	348	117	51	48	300
E00042929	258	85	38	53	205

E00042930	199	57	48	22	177
E00175550	249	93	44	12	237
E00175551	225	67	61	10	215
E00175551	225	67	61	10	215
E00175552	223	100	50	7	216
E00175553	236	80	41	1	235
E00175553	236	80	41	1	235
E00175554	443	135	46	56	387
E00175554	443	135	46	56	387
E00175555	417	55	57	4	413
E00175556	124	51	24	19	105
E00175556	124	51	24	19	105
E00175556	124	51	24	19	105
E00175557	144	56	33	4	140
E00175558	216	68	53	6	210
E00175558	216	68	53	6	210
E00175559	206	66	57	7	199
E00175560	202	61	68	16	186
E00175561	225	112	27	2	223
E00175561	225	112	27	2	223
E00175562	349	99	29	54	295
E00175563	192	43	80	6	186
E00175564	354	38	34	3	351
E00175565	559	30	47	25	534
E00175566	241	59	57	59	182
E00175567	370	28	89	45	325
E00175568	348	20	93	46	302
E00175569	371	18	96	61	310
E00175570	396	30	86	46	350
E00175571	289	33	88	37	252
E00175572	150	60	25	37	113
E00175573	330	28	90	40	290
E00175574	623	31	32	2	621
E00175575	194	80	45	9	185
E00175576	165	69	44	2	163
E00175577	375	101	38	99	276
E00175577	375	101	38	99	276
E00175578	891	81	29	9	882
E00175578	891	81	29	9	882
E00175579	167	75	52	2	165
E00175580	237	64	89	9	228
E00175581	261	106	23	28	233
E00175582	363	117	38	60	303
E00175583	239	69	35	23	216
E00175584	1346	30	14	17	1329

E00175585	201	50	43	1	200
E00175586	336	95	24	62	274
E00175586	336	95	24	62	274
E00175587	150	61	40	32	118
E00175588	167	86	19	33	134
E00175589	500	63	41	34	466
E00175590	206	33	65	22	184
E00175591	265	26	76	29	236
E00175592	201	123	15	42	160
E00175593	600	55	55	2	598
E00175594	282	41	43	3	279
E00175594	282	41	43	3	279
E00175595	116	48	14	0	116
E00175596	279	75	25	34	245
E00175597	421	101	46	36	385
E00175597	421	101	46	36	385
E00175597	421	101	46	36	385
E00175598	612	40	48	4	608
E00175599	364	153	46	65	299
E00175600	150	61	28	15	135
E00175601	156	28	32	23	133
E00175602	227	23	67	26	201
E00175603	259	49	43	36	223
E00175603	259	49	43	36	223
E00175604	232	47	51	24	208
E00175605	214	51	38	34	180
Total	**405105**	**97670**	**69296**	**50667**	**354514**

Appendix F: The Calculation Process of the Number of Residents and Social Groups with Potential Accessibility to All GP Practices by Service Area in Newcastle Applying the PWC Method

Output Area with Access	No. of Resident	No. of Deprived Household	No. of Non-Deprived Household	No. of Heavy User Group	No. of Light User Group
Service Area 1					
E00042579	152	117	35	9	187
E00042580	184	98	86	5	442
E00042583	60	35	25	5	169
E00042609	149	65	84	24	472
E00042826	242	148	94	7	393
E00175553	121	80	41	1	235
E00175558	121	68	53	6	210
E00175561	139	112	27	2	223
Subtotal 1	1168	723	445	59	2331
Service Area 2					
E00042579	152	117	35	9	187
E00042583	60	35	25	5	169
E00042671	88	63	25	16	110
E00042672	90	71	19	13	1148
E00042673	173	117	56	25	315
E00042679	108	71	37	1	589
E00175561	139	112	27	2	223
E00175574	63	31	32	2	621
E00175595	62	48	14	0	116
Subtotal 2	935	665	270	73	3478
Service Area 3					
E00042693	145	122	23	52	284
E00042697	157	131	26	75	262
E00175581	129	106	23	28	233

E00175586	119	95	24	62	274
E00175597	147	101	46	36	385
Subtotal 3	697	555	142	253	1438
Service Area 4					
E00042052	184	126	58	56	273
E00042057	122	97	25	61	332
E00042058	48	34	14	13	111
E00042691	85	76	9	33	172
E00042695	133	130	3	84	105
E00042697	157	131	26	75	262
E00175554	181	135	46	56	387
E00175597	147	101	46	36	385
Subtotal 4	1057	830	227	414	2027
Service Area 5					
E00042043	143	62	81	37	303
E00042048	146	76	70	58	297
E00042051	128	71	57	34	278
E00042054	138	80	58	40	251
E00042685	54	41	13	20	100
E00042686	121	73	48	43	243
E00042687	122	75	47	40	266
E00042688	114	65	49	24	222
E00042689	134	89	45	40	301
E00042690	129	95	34	45	257
E00042702	119	79	40	23	246
E00042703	120	67	53	31	219
E00042704	125	64	61	34	285
E00042705	121	65	56	32	228
Subtotal 5	1714	1002	712	501	3496
Service Area 6					

E00042611	167	84	83	41	303
E00042612	123	104	19	57	141
E00042634	121	78	43	41	278
E00042636	143	86	57	41	233
E00042637	240	128	112	76	458
E00042638	129	86	43	21	230
Subtotal 6	923	566	357	277	1643
Service Area 7					
E00042615	127	71	56	42	244
E00042619	118	62	56	58	220
E00042620	120	74	46	37	221
E00042621	117	90	27	37	218
E00042623	121	91	30	36	264
E00042624	137	81	56	46	293
E00042627	116	83	33	55	199
E00042628	132	97	35	86	300
E00042629	142	113	29	64	223
E00042630	79	63	16	22	130
E00042631	119	85	34	21	177
E00042632	129	97	32	48	215
E00042635	111	72	39	23	196
Subtotal 7	1568	1079	489	575	2900
Service Area 8					
E00042642	174	90	84	24	389
E00042643	151	76	75	28	413
E00042644	120	48	72	13	320
E00042645	172	73	99	8	435
E00042646	122	99	23	25	230
E00042650	148	60	88	27	329
E00042653	164	61	103	2	465

E00042655	95	45	50	6	241
E00042661	90	74	16	10	100
E00042663	92	46	46	13	219
E00042665	129	115	14	30	122
E00042667	80	31	49	6	192
E00042669	49	35	14	9	252
E00042670	146	111	35	40	329
E00042671	88	63	25	16	110
E00042672	90	71	19	13	1148
E00042673	173	117	56	25	315
E00042674	168	128	40	52	195
E00042677	158	115	43	29	215
E00175555	112	55	57	4	413
E00175556	75	51	24	19	105
E00175578	110	81	29	9	882
E00175583	104	69	35	23	216
E00175588	105	86	19	33	134
E00175594	84	41	43	3	279
Subtotal 8	2999	1841	1158	467	8048
Service Area 9					
E00042439	197	86	111	9	589
E00042440	126	46	80	24	331
E00042441	176	75	101	18	411
E00042442	156	46	110	11	513
E00042443	183	64	119	8	416
E00042448	142	33	109	9	533
E00042451	165	74	91	15	364
E00042453	128	71	57	26	260
E00042455	131	44	87	43	387
E00042457	145	51	94	4	612

E00042458	167	63	104	18	417
E00042459	131	42	89	15	460
E00042460	123	42	81	12	402
E00042461	126	34	92	26	358
E00042462	144	54	90	25	423
E00042463	149	55	94	17	373
E00042464	161	56	105	31	286
E00042465	121	50	71	1	435
E00042466	119	45	74	91	210
E00042468	227	93	134	39	409
E00042469	132	81	51	38	188
E00042471	135	54	81	33	293
Subtotal 9	3284	1259	2025	513	8670
Service Area 10					
E00042439	197	86	111	9	589
E00042440	126	46	80	24	331
E00042441	176	75	101	18	411
E00042442	156	46	110	11	513
E00042443	183	64	119	8	416
E00042447	133	53	80	6	379
E00042448	142	33	109	9	533
E00042451	165	74	91	15	364
E00042453	128	71	57	26	260
E00042455	131	44	87	43	387
E00042457	145	51	94	4	612
E00042458	167	63	104	18	417
E00042459	131	42	89	15	460
E00042460	123	42	81	12	402
E00042461	126	34	92	26	358
E00042462	144	54	90	25	423

E00042463	149	55	94	17	373
E00042464	161	56	105	31	286
E00042466	119	45	74	91	210
E00042468	227	93	134	39	409
E00042469	132	81	51	38	188
E00042471	135	54	81	33	293
Subtotal 10	3296	1262	2034	518	8614
Service Area 11					
E00042444	155	54	101	10	422
E00042446	122	44	78	11	341
E00042447	133	53	80	6	379
E00042448	142	33	109	9	533
E00042449	106	24	82	16	305
E00042450	183	50	133	7	602
E00042451	165	74	91	15	364
E00042453	128	71	57	26	260
E00042458	167	63	104	18	417
E00042470	133	33	100	33	338
E00042471	135	54	81	33	293
E00042473	116	31	85	34	315
E00042475	101	27	74	3	335
E00042476	145	46	99	8	504
E00042477	147	47	100	10	450
E00042708	116	29	87	24	268
E00042709	132	58	74	44	288
E00042726	146	33	113	24	300
E00042727	139	37	102	17	337
Subtotal 11	2611	861	1750	348	7051
Service Area 12					
E00042370	155	115	40	101	166

E00042371	149	55	94	40	266
E00042374	124	27	97	30	280
E00042375	137	68	69	46	231
E00042378	134	39	95	41	312
E00042379	170	52	118	29	323
E00042735	113	27	86	25	225
E00042739	112	25	87	38	281
Subtotal 12	1094	408	686	350	2084
Service Area 13					
E00042706	141	42	99	55	318
E00042707	153	32	121	65	351
E00042708	116	29	87	24	268
E00042710	145	55	90	43	281
E00042712	136	36	100	32	269
E00042713	238	99	139	138	372
E00042717	233	85	148	43	501
E00042725	148	49	99	83	305
E00042726	146	33	113	24	300
E00042727	139	37	102	17	337
E00042728	124	33	91	42	312
E00042729	116	27	89	35	279
E00042730	145	76	69	79	259
Subtotal 13	1980	633	1347	680	4152
Service Area 14					
E00042706	141	42	99	55	318
E00042707	153	32	121	65	351
E00042710	145	55	90	43	281
E00042712	136	36	100	32	269
E00042713	238	99	139	138	372
E00042717	233	85	148	43	501

E00042725	148	49	99	83	305
E00042726	146	33	113	24	300
E00042728	124	33	91	42	312
E00042729	116	27	89	35	279
E00042735	113	27	86	25	225
E00042739	112	25	87	38	281
Subtotal 14	1805	543	1262	623	3794
Service Area 15					
E00042366	124	77	47	27	226
E00042370	155	115	40	101	166
E00042371	149	55	94	40	266
E00042372	125	88	37	42	217
E00042373	126	35	91	43	317
E00042374	124	27	97	30	280
E00042375	137	68	69	46	231
E00042378	134	39	95	41	312
E00042379	170	52	118	29	323
E00042381	121	41	80	33	246
E00042382	147	83	64	50	197
E00042706	141	42	99	55	318
E00042707	153	32	121	65	351
E00042711	118	28	90	24	212
E00042712	136	36	100	32	269
E00042713	238	99	139	138	372
E00042717	233	85	148	43	501
E00042735	113	27	86	25	225
E00042739	112	25	87	38	281
Subtotal 15	2756	1054	1702	902	5310
Service Area 16					
E00042068	120	61	59	35	285

E00042082	124	52	72	54	242
E00042084	120	48	72	12	224
E00042140	125	72	53	36	258
E00042141	133	57	76	45	307
E00042149	126	55	71	32	288
Subtotal 16	748	345	403	214	1604
Service Area 17					
E00042289	132	101	31	57	206
E00042290	141	100	41	43	222
E00042291	125	80	45	35	225
E00042293	131	64	67	41	251
E00042294	133	81	52	40	238
E00042296	146	115	31	41	215
E00042297	130	72	58	38	251
E00042312	124	83	41	49	213
E00042313	113	78	35	37	264
E00042315	117	77	40	42	226
E00042316	131	92	39	48	295
E00042317	135	94	41	52	325
E00042319	119	69	50	45	256
E00042321	82	63	19	58	100
E00042322	122	87	35	49	207
E00042369	111	84	27	37	183
Subtotal 17	1992	1340	652	712	3677
Service Area 18					
E00042072	117	86	31	39	239
E00042073	114	73	41	41	287
E00042295	134	107	27	29	340
E00042296	146	115	31	41	215
E00042299	137	97	40	30	310

E00042300	121	90	31	31	246
E00042301	127	93	34	45	289
E00042303	137	99	38	43	182
E00042304	143	103	40	40	257
E00042306	134	88	46	37	209
E00042308	117	94	23	42	294
E00042510	123	94	29	38	256
Subtotal 18	1550	1139	411	456	3124
Service Area 19					
E00042072	117	86	31	39	239
E00042295	134	107	27	29	340
E00042299	137	97	40	30	310
E00042301	127	93	34	45	289
E00042303	137	99	38	43	182
E00042304	143	103	40	40	257
E00042305	145	112	33	45	282
E00042306	134	88	46	37	209
E00042307	95	70	25	38	227
E00042308	117	94	23	42	294
E00042480	124	59	65	41	280
E00042484	114	52	62	29	242
E00042485	126	77	49	48	254
E00042489	112	46	66	36	259
E00042510	123	94	29	38	256
E00042511	122	62	60	46	248
E00042512	118	44	74	42	268
Subtotal 19	2125	1383	742	668	4436
Service Area 20					
E00042363	117	53	64	49	245
E00042386	119	43	76	30	283

E00042387	108	43	65	37	195
E00042388	215	97	118	91	358
E00042389	96	30	66	31	243
E00042390	97	70	27	37	127
E00042391	101	43	58	35	244
E00042392	115	77	38	25	171
E00042393	120	85	35	29	265
E00042394	118	58	60	42	288
E00042395	104	69	35	37	163
E00042396	131	88	43	40	163
E00042397	216	65	151	53	387
Subtotal 20	1657	821	836	536	3132
Service Area 21					
E00042169	118	48	70	66	225
E00042170	121	48	73	49	265
E00042173	117	41	76	54	260
E00042174	122	50	72	92	225
E00042176	129	49	80	55	285
E00042177	121	56	65	74	179
E00042178	135	45	90	49	288
E00175566	116	59	57	59	182
Subtotal 21	979	396	583	498	1909
Service Area 22					
E00042581	126	107	19	56	205
E00042582	118	94	24	37	226
E00042587	127	100	27	38	257
E00042588	130	94	36	45	325
E00042606	147	91	56	39	367
E00042607	141	91	50	47	336
E00042608	144	100	44	66	377

E00042874	166	91	75	34	523
E00042877	141	81	60	47	439
E00042899	147	79	68	42	451
E00042900	138	61	77	33	476
E00042901	110	56	54	24	336
Subtotal 22	1635	1045	590	508	4318
Service Area 23					
E00042272	157	104	53	95	514
E00042276	114	83	31	52	320
E00042277	119	87	32	28	385
E00042282	106	69	37	40	270
E00042284	144	118	26	59	430
E00042285	136	103	33	55	349
E00042287	110	91	19	32	266
E00042588	130	94	36	45	325
E00042808	119	92	27	48	227
E00042811	124	110	14	32	359
E00042812	148	136	12	32	146
E00175577	139	101	38	99	276
Subtotal 23	1546	1188	358	617	3867
Service Area 24					
E00042287	110	91	19	32	266
E00042805	135	126	9	34	188
E00042806	118	86	32	38	255
E00042807	143	121	22	17	178
E00042810	117	100	17	36	280
E00042811	124	110	14	32	359
E00042812	148	136	12	32	146
E00042814	120	100	20	54	202
E00042816	54	41	13	13	115

E00042818	154	130	24	12	179
E00042819	138	104	34	2	169
E00042823	139	118	21	36	249
E00042824	142	127	15	55	259
E00042827	136	110	26	50	352
E00042828	135	79	56	30	283
Subtotal 24	1913	1579	334	473	3480
Service Area 25					
E00042262	174	123	51	64	470
E00042266	173	122	51	78	434
E00042267	123	80	43	56	345
E00042271	131	74	57	61	384
E00042272	157	104	53	95	514
E00042273	128	91	37	59	404
E00042275	128	83	45	65	403
E00042276	114	83	31	52	320
E00042277	119	87	32	28	385
E00042279	112	85	27	90	304
E00042281	133	79	54	57	296
E00042282	106	69	37	40	270
E00042286	162	106	56	66	328
E00042357	124	80	44	77	394
E00042588	130	94	36	45	325
E00042608	144	100	44	66	377
E00042873	137	75	62	26	299
E00042874	166	91	75	34	523
E00042875	125	79	46	39	321
E00042877	141	81	60	47	439
E00042878	129	74	55	88	399
E00042879	122	85	37	52	378

E00042898	126	71	55	42	315
E00042899	147	79	68	42	451
E00042902	123	73	50	62	310
E00042903	137	87	50	48	326
Subtotal 25	3511	2255	1256	1479	9714
Service Area 26					
E00042046	161	118	43	50	411
E00042047	154	116	38	45	301
E00042056	113	87	26	56	180
E00042059	135	101	34	52	272
E00042061	139	116	23	59	283
E00042062	178	137	41	73	428
E00042064	171	136	35	66	285
E00042065	143	117	26	29	269
E00042066	98	84	14	29	103
E00042269	158	123	35	63	342
E00042270	137	91	46	52	348
E00042274	125	90	35	45	246
E00042278	115	104	11	42	214
E00042283	145	139	6	51	131
E00042286	162	106	56	66	328
E00175597	147	101	46	36	385
Subtotal 26	2281	1766	515	814	4526
Service Area 27					
E00042262	174	123	51	64	470
E00042263	152	94	58	44	296
E00042264	132	85	47	51	237
E00042265	140	95	45	56	310
E00042266	173	122	51	78	434
E00042267	123	80	43	56	345

E00042268	111	78	33	33	210
E00042269	158	123	35	63	342
E00042270	137	91	46	52	348
E00042273	128	91	37	59	404
E00042274	125	90	35	45	246
E00042278	115	104	11	42	214
E00042280	177	135	42	62	432
E00042348	95	70	25	40	269
E00042354	114	74	40	43	282
E00042355	122	74	48	48	307
E00042356	122	70	52	45	369
E00042357	124	80	44	77	394
E00042875	125	79	46	39	321
E00042879	122	85	37	52	378
E00042902	123	73	50	62	310
Subtotal 27	2792	1916	876	1111	6918
Service Area 28					
E00042323	141	80	61	45	271
E00042325	119	74	45	42	215
E00042328	137	86	51	58	311
E00042339	146	112	34	50	268
E00042340	111	78	33	30	246
E00042341	108	55	53	38	230
E00042344	102	51	51	20	182
E00042345	106	65	41	49	245
E00042349	132	70	62	55	334
E00042881	128	66	62	27	251
E00042882	135	99	36	51	337
E00042884	129	68	61	35	209
E00042885	133	82	51	40	249

E00042886	160	75	85	44	236
E00042887	135	85	50	58	288
E00042888	145	97	48	50	289
E00042890	159	116	43	70	336
E00042892	135	98	37	62	285
E00042893	116	57	59	43	270
E00042894	112	68	44	54	306
E00175596	100	75	25	34	245
E00175598	88	40	48	4	608
Subtotal 28	2777	1697	1080	959	6211
Service Area 29					
E00042229	123	62	61	36	226
E00042236	112	73	39	49	178
E00042249	116	66	50	51	200
E00042250	111	61	50	46	212
E00042253	117	67	50	60	200
E00042257	116	70	46	59	208
E00042835	122	68	54	50	213
E00042839	120	78	42	56	192
E00042842	119	64	55	44	224
E00042845	117	65	52	58	187
E00042846	132	87	45	60	199
E00042854	117	74	43	53	194
E00042855	121	66	55	43	215
E00042856	122	67	55	45	226
E00042858	125	66	59	48	240
E00042862	123	80	43	58	190
Subtotal 29	1913	1114	799	816	3304
Service Area 30					
E00042229	123	62	61	36	226

E00042249	116	66	50	51	200
E00042250	111	61	50	46	212
E00042253	117	67	50	60	200
E00042257	116	70	46	59	208
E00042835	122	68	54	50	213
E00042839	120	78	42	56	192
E00042842	119	64	55	44	224
E00042845	117	65	52	58	187
E00042846	132	87	45	60	199
E00042854	117	74	43	53	194
E00042855	121	66	55	43	215
E00042856	122	67	55	45	226
E00042858	125	66	59	48	240
E00042862	123	80	43	58	190
Subtotal 30	1801	1041	760	767	3126
Service Area 31					
E00042228	193	147	46	120	304
E00042246	97	69	28	36	199
E00042831	134	96	38	93	264
E00042836	118	69	49	43	266
E00042843	145	100	45	67	245
E00042851	129	79	50	37	258
E00042857	140	79	61	34	309
E00042863	134	83	51	49	265
Subtotal 31	1090	722	368	479	2110
Service Area 32					
E00042229	123	62	61	36	226
E00042233	133	88	45	47	257
E00042237	44	33	11	19	100
E00042240	130	101	29	49	238

E00042241	123	95	28	58	194
E00042242	125	89	36	43	234
E00042243	112	72	40	32	225
E00042244	129	75	54	52	277
E00042247	122	113	9	82	80
E00042254	133	79	54	31	251
E00042255	133	92	41	49	277
E00042256	140	102	38	52	271
E00042258	132	100	32	27	262
E00042261	145	108	37	53	227
E00042853	123	80	43	56	195
E00042860	127	81	46	62	206
E00042861	134	87	47	48	214
Subtotal 32	2108	1457	651	796	3734
Service Area 33					
E00042324	158	98	60	52	281
E00042330	120	92	28	39	168
E00042334	140	108	32	46	235
E00042335	142	100	42	44	275
E00042336	155	116	39	75	180
E00042337	139	93	46	60	250
E00042338	160	109	51	64	330
E00042347	151	104	47	42	270
E00042686	121	73	48	43	243
E00042687	122	75	47	40	266
E00042688	114	65	49	24	222
E00042702	119	79	40	23	246
E00042703	120	67	53	31	219
E00042704	125	64	61	34	285
E00042705	121	65	56	32	228

Subtotal 33	2007	1308	699	649	3698
Service Area 34					
E00042087	112	85	27	46	258
E00042088	142	71	71	38	322
E00042089	121	113	8	33	161
E00042100	115	67	48	92	235
E00042104	175	117	58	70	418
E00042478	146	108	38	37	330
E00042479	135	116	19	64	247
E00042505	109	65	44	32	228
E00042507	179	148	31	64	403
E00042508	135	94	41	36	159
E00042509	144	104	40	66	296
E00042881	128	66	62	27	251
E00042882	135	99	36	51	337
E00042884	129	68	61	35	209
Subtotal 34	1905	1321	584	691	3854
Service Area 35					
E00042088	142	71	71	38	322
E00042090	122	84	38	40	227
E00042091	128	94	34	45	317
E00042100	115	67	48	92	235
E00042101	117	100	17	45	198
E00042103	131	101	30	43	280
E00042104	175	117	58	70	418
E00042106	118	89	29	42	321
E00042478	146	108	38	37	330
E00042479	135	116	19	64	247
E00042503	118	85	33	42	325
E00042505	109	65	44	32	228

E00042507	179	148	31	64	403
E00175603	92	49	43	36	223
Subtotal 35	1827	1294	533	690	4074
Service Area 36					
E00042070	112	70	42	37	250
E00042078	130	64	66	32	224
E00042080	122	90	32	34	214
E00042904	123	101	22	50	269
E00042905	119	93	26	25	175
E00042906	130	105	25	51	221
E00042908	141	96	45	36	272
E00042916	113	88	25	100	287
E00042919	137	95	42	53	306
E00042920	118	88	30	71	303
E00042924	111	82	29	48	211
E00042925	121	101	20	60	191
E00042926	116	90	26	63	240
E00042927	120	102	18	41	227
E00042930	105	57	48	22	177
Subtotal 36	1818	1322	496	723	3567
Service Area 37					
E00042111	136	105	31	44	183
E00042112	155	125	30	45	235
E00042125	131	99	32	15	193
E00042126	231	186	45	33	295
E00042127	147	103	44	34	308
E00042128	125	92	33	29	139
E00042129	200	156	44	68	398
E00042132	134	102	32	15	210
E00042133	157	117	40	28	251

E00042136	150	117	33	42	243
E00042414	98	38	60	10	222
E00042415	153	79	74	17	311
E00042434	133	67	66	24	235
E00042435	133	69	64	18	336
E00042436	110	49	61	10	222
E00042437	131	69	62	26	291
E00042438	125	66	59	12	389
E00042652	116	44	72	17	201
E00042656	136	52	84	31	327
E00042658	123	61	62	18	353
E00042659	126	45	81	24	349
E00042664	127	80	47	20	249
Subtotal 37	3077	1921	1156	580	5940
Service Area 38					
E00042111	136	105	31	44	183
E00042112	155	125	30	45	235
E00042115	138	117	21	48	251
E00042125	131	99	32	15	193
E00042127	147	103	44	34	308
E00042128	125	92	33	29	139
E00042129	200	156	44	68	398
E00042132	134	102	32	15	210
E00042134	140	101	39	34	265
E00042136	150	117	33	42	243
E00042438	125	66	59	12	389
E00042643	151	76	75	28	413
E00042647	95	49	46	15	203
E00042656	136	52	84	31	327
E00042657	141	52	89	26	382

E00042658	123	61	62	18	353
E00042659	126	45	81	24	349
E00042662	118	53	65	12	288
E00042664	127	80	47	20	249
E00042666	147	91	56	16	318
E00042668	122	63	59	10	271
Subtotal 38	2867	1805	1062	586	5967
Service Area 39					
E00042111	136	105	31	44	183
E00042112	155	125	30	45	235
E00042115	138	117	21	48	251
E00042125	131	99	32	15	193
E00042127	147	103	44	34	308
E00042128	125	92	33	29	139
E00042129	200	156	44	68	398
E00042132	134	102	32	15	210
E00042134	140	101	39	34	265
E00042136	150	117	33	42	243
E00042438	124	100	24	42	259
E00042643	151	76	75	28	413
E00042647	95	49	46	15	203
E00042656	136	52	84	31	327
E00042657	141	52	89	26	382
E00042658	123	61	62	18	353
E00042659	126	45	81	24	349
E00042662	118	53	65	12	288
E00042664	127	80	47	20	249
E00042666	147	91	56	16	318
E00042668	122	63	59	10	271
Subtotal 39	2866	1839	1027	616	5837

Service Area 40					
E00042549	152	109	43	52	334
E00042550	142	115	27	36	282
E00042551	128	108	20	43	253
E00042552	115	102	13	46	124
E00042553	141	102	39	42	300
E00042554	127	80	47	40	246
E00042555	161	118	43	61	319
E00042572	129	91	38	39	265
E00042573	101	80	21	35	168
E00042574	152	110	42	52	276
E00042575	139	111	28	37	271
E00042740	134	116	18	51	285
E00042742	129	106	23	33	289
E00042745	125	95	30	109	280
E00042752	57	45	12	15	104
E00042754	104	93	11	38	187
E00042755	94	83	11	13	122
E00175582	155	117	38	60	303
Subtotal 40	2285	1781	504	802	4408
Service Area 41					
E00042747	135	74	61	15	238
E00042750	94	85	9	25	132
E00042756	124	91	33	33	269
E00042757	112	89	23	34	179
E00042759	132	118	14	95	232
E00042760	153	124	29	98	244
E00042765	196	160	36	9	242
E00042766	163	138	25	52	216
E00042767	153	106	47	51	299

E00042771	126	83	43	40	219
E00042778	126	87	39	36	195
Subtotal 41	1514	1155	359	488	2465
Service Area 42					
E00042557	132	79	53	25	281
E00042558	110	71	39	19	181
E00042772	131	64	67	36	298
E00042773	118	82	36	57	175
E00042781	119	82	37	46	187
E00042784	123	90	33	52	167
E00042794	143	77	66	43	323
E00042795	144	87	57	47	311
Subtotal 42	1020	632	388	325	1923
Service Area 43					
E00042404	141	58	83	60	292
E00042405	130	42	88	25	243
E00042407	110	42	68	45	253
E00042408	119	50	69	33	340
E00042409	147	51	96	27	245
E00042410	161	53	108	12	294
E00042411	114	52	62	3	247
E00042416	123	70	53	33	200
E00042417	135	89	46	52	195
E00042418	124	47	77	16	287
E00042419	175	57	118	24	381
E00042420	136	59	77	44	224
E00042421	104	39	65	22	196
E00042422	121	36	85	38	318
E00042424	139	44	95	19	291
E00042425	113	41	72	30	298

E00042426	136	52	84	12	314
E00042427	176	72	104	16	372
E00042428	160	62	98	8	336
E00042429	94	38	56	15	308
E00042430	120	39	81	20	224
E00042431	91	43	48	16	233
Subtotal 43	2869	1136	1733	570	6091
Service Area 44					
E00042190	131	58	73	58	297
E00042197	107	64	43	45	221
E00042199	123	63	60	44	244
E00042200	125	80	45	47	237
E00042203	105	77	28	34	203
E00042206	125	68	57	27	242
E00175590	98	33	65	22	184
Subtotal 44	814	443	371	277	1628

Appendix G: Output Areas Involved in the Calculation of the Denominator Taking into Consideration Overlays of Service Areas in Newcastle Applying the PWC Method

OA Code	Resident	Deprived Household	Non-Deprived Household	Heavy User Group	Light User Group
E00042042	268	97	14	33	235
E00042043	340	62	81	37	303
E00042044	264	74	43	26	238
E00042045	234	91	27	30	204
E00042046	461	118	43	50	411
E00042047	346	116	38	45	301
E00042048	354	76	70	58	297
E00042049	336	74	69	52	284
E00042050	384	94	48	93	295
E00042051	312	71	57	34	278
E00042052	329	126	58	56	273
E00042053	309	82	33	46	263
E00042054	291	80	58	40	251
E00042055	313	63	76	30	284
E00042056	236	87	26	56	180
E00042057	393	97	25	61	332
E00042058	124	34	14	13	111
E00042059	324	101	34	52	272
E00042061	342	116	23	59	283
E00042062	501	137	41	73	428
E00042064	351	136	35	66	285
E00042065	298	117	26	29	269
E00042066	132	84	14	29	103
E00042067	353	58	71	45	308
E00042068	320	61	59	35	285
E00042069	334	73	65	44	290
E00042070	287	70	42	37	250
E00042071	275	62	60	35	240
E00042072	278	86	31	39	239
E00042072	278	86	31	39	239
E00042073	328	73	41	41	287
E00042074	250	82	28	30	220
E00042075	361	100	34	77	284
E00042076	371	93	36	70	301
E00042077	245	53	58	25	220
E00042078	256	64	66	32	224
E00042079	244	79	37	23	221
E00042080	248	90	32	34	214
E00042081	433	42	97	47	386
E00042082	295	52	72	54	242
E00042083	313	52	73	29	284

E00042084	236	48	72	12	224
E00042085	246	106	27	59	189
E00042086	335	87	40	29	306
E00042087	304	85	27	46	258
E00042088	360	71	71	38	322
E00042088	360	71	71	38	322
E00042089	194	113	8	33	161
E00042090	267	84	38	40	227
E00042091	362	94	34	45	317
E00042092	295	79	58	21	274
E00042093	253	89	28	27	226
E00042094	201	85	24	33	169
E00042095	281	87	35	47	234
E00042096	218	93	22	43	175
E00042097	396	131	54	77	319
E00042099	397	107	31	50	347
E00042100	326	67	48	92	235
E00042100	326	67	48	92	235
E00042101	243	100	17	45	198
E00042102	399	100	39	53	346
E00042103	323	101	30	43	280
E00042104	488	117	58	70	418
E00042104	488	117	58	70	418
E00042106	363	89	29	42	321
E00042107	263	100	25	42	221
E00042108	309	114	27	50	260
E00042109	298	138	29	52	246
E00042110	250	100	34	29	221
E00042111	227	105	31	44	183
E00042111	227	105	31	44	183
E00042111	227	105	31	44	183
E00042112	280	125	30	45	235
E00042112	280	125	30	45	235
E00042112	280	125	30	45	235
E00042113	279	98	24	42	237
E00042114	256	86	68	20	236
E00042115	299	117	21	48	251
E00042115	299	117	21	48	251
E00042116	255	72	45	25	230
E00042117	227	39	87	8	219
E00042118	460	117	25	117	343
E00042120	342	111	41	43	299
E00042121	284	76	58	21	263
E00042122	257	82	45	25	232
E00042123	210	44	61	14	196

E00042124	206	51	84	10	196
E00042125	208	99	32	15	193
E00042125	208	99	32	15	193
E00042125	208	99	32	15	193
E00042126	328	186	45	33	295
E00042127	342	103	44	34	308
E00042127	342	103	44	34	308
E00042127	342	103	44	34	308
E00042128	168	92	33	29	139
E00042128	168	92	33	29	139
E00042128	168	92	33	29	139
E00042129	465	156	44	68	398
E00042129	465	156	44	68	398
E00042129	465	156	44	68	398
E00042130	280	115	20	48	232
E00042131	216	113	27	32	184
E00042132	225	102	32	15	210
E00042132	225	102	32	15	210
E00042132	225	102	32	15	210
E00042133	279	117	40	28	251
E00042134	299	101	39	34	265
E00042134	299	101	39	34	265
E00042135	267	106	20	43	224
E00042136	285	117	33	42	243
E00042136	285	117	33	42	243
E00042136	285	117	33	42	243
E00042137	245	86	38	26	219
E00042138	301	100	24	42	259
E00042139	263	91	22	56	207
E00042140	294	72	53	36	258
E00042141	352	57	76	45	307
E00042142	324	46	76	32	292
E00042143	299	50	74	32	267
E00042144	279	48	72	28	251
E00042145	274	61	57	34	240
E00042146	294	50	74	24	270
E00042147	526	69	135	91	435
E00042148	304	38	85	29	275
E00042149	320	55	71	32	288
E00042150	293	43	77	15	278
E00042151	278	57	59	29	249
E00042152	321	46	67	30	291
E00042153	256	88	38	39	217
E00042154	271	59	75	36	235
E00042155	286	88	28	64	222

E00042156	216	87	37	46	170
E00042157	274	63	61	28	246
E00042158	305	72	58	55	250
E00042159	313	95	44	37	276
E00042160	297	95	33	48	249
E00042161	294	80	54	36	258
E00042162	153	43	22	25	128
E00042164	259	69	50	24	235
E00042165	278	76	37	29	249
E00042166	229	76	32	36	193
E00042168	265	57	68	47	218
E00042169	291	48	70	66	225
E00042170	314	48	73	49	265
E00042171	312	48	75	45	267
E00042172	228	38	70	28	200
E00042173	314	41	76	54	260
E00042174	317	50	72	92	225
E00042175	323	51	73	58	265
E00042176	340	49	80	55	285
E00042177	253	56	65	74	179
E00042178	337	45	90	49	288
E00042179	260	58	102	37	223
E00042180	539	59	133	52	487
E00042182	385	44	92	43	342
E00042183	317	64	53	37	280
E00042184	429	95	97	73	356
E00042185	339	50	79	54	285
E00042186	189	27	86	8	181
E00042187	586	101	119	75	511
E00042188	340	73	61	36	304
E00042189	268	50	64	60	209
E00042190	355	58	73	58	297
E00042191	256	49	60	38	218
E00042192	226	36	42	17	209
E00042193	317	78	43	45	272
E00042194	336	84	54	54	282
E00042195	351	85	59	43	308
E00042196	311	49	92	36	275
E00042197	266	64	43	45	221
E00042198	257	62	63	52	205
E00042199	288	63	60	44	244
E00042200	284	80	45	47	237
E00042201	299	43	75	39	260
E00042202	331	49	79	42	289
E00042203	237	77	28	34	203

E00042205	309	62	56	47	262
E00042206	269	68	57	27	242
E00042207	330	42	91	39	291
E00042208	234	55	43	38	196
E00042209	275	47	71	63	213
E00042210	292	50	58	47	245
E00042211	271	34	73	52	219
E00042212	307	55	59	34	273
E00042213	452	31	115	42	410
E00042214	282	62	51	47	235
E00042215	304	46	67	33	271
E00042216	267	49	67	34	233
E00042217	326	58	61	58	268
E00042218	301	65	50	54	247
E00042219	328	57	70	41	287
E00042220	353	37	94	24	329
E00042221	200	52	67	29	171
E00042222	303	83	43	40	263
E00042223	297	53	66	43	254
E00042224	292	37	81	24	268
E00042225	291	57	65	55	236
E00042226	157	107	12	59	98
E00042227	255	74	45	26	229
E00042228	424	147	46	120	304
E00042229	262	62	61	36	226
E00042229	262	62	61	36	226
E00042229	262	62	61	36	226
E00042230	324	106	22	44	280
E00042232	325	50	65	37	288
E00042233	304	88	45	47	257
E00042234	340	59	58	75	265
E00042235	290	67	50	36	254
E00042236	227	73	39	49	178
E00042237	119	33	11	19	100
E00042238	366	90	34	52	314
E00042240	287	101	29	49	238
E00042241	252	95	28	58	194
E00042242	276	89	36	43	234
E00042243	257	72	40	32	225
E00042244	329	75	54	52	277
E00042245	451	117	78	79	372
E00042246	235	69	28	36	199
E00042247	162	113	9	82	80
E00042248	272	56	64	46	226
E00042249	250	66	50	51	200

E00042249	250	66	50	51	200
E00042250	258	61	50	46	212
E00042250	258	61	50	46	212
E00042251	365	85	39	55	310
E00042252	221	110	19	66	155
E00042253	260	67	50	60	200
E00042253	260	67	50	60	200
E00042254	282	79	54	31	251
E00042255	326	92	41	49	277
E00042256	323	102	38	52	271
E00042257	267	70	46	59	208
E00042257	267	70	46	59	208
E00042258	289	100	32	27	262
E00042259	294	55	56	51	243
E00042260	386	94	36	42	344
E00042261	280	108	37	53	227
E00042262	534	123	51	64	470
E00042262	534	123	51	64	470
E00042263	340	94	58	44	296
E00042264	288	85	47	51	237
E00042265	366	95	45	56	310
E00042266	512	122	51	78	434
E00042266	512	122	51	78	434
E00042267	401	80	43	56	345
E00042267	401	80	43	56	345
E00042268	243	78	33	33	210
E00042269	405	123	35	63	342
E00042269	405	123	35	63	342
E00042270	400	91	46	52	348
E00042270	400	91	46	52	348
E00042271	445	74	57	61	384
E00042272	608	104	53	95	514
E00042272	608	104	53	95	514
E00042273	463	91	37	59	404
E00042273	463	91	37	59	404
E00042274	291	90	35	45	246
E00042274	291	90	35	45	246
E00042275	468	83	45	65	403
E00042276	372	83	31	52	320
E00042276	372	83	31	52	320
E00042277	413	87	32	28	385
E00042277	413	87	32	28	385
E00042278	256	104	11	42	214
E00042278	256	104	11	42	214
E00042279	394	85	27	90	304

E00042280	494	135	42	62	432
E00042281	353	79	54	57	296
E00042282	310	69	37	40	270
E00042282	310	69	37	40	270
E00042283	182	139	6	51	131
E00042284	489	118	26	59	430
E00042285	404	103	33	55	349
E00042286	394	106	56	66	328
E00042286	394	106	56	66	328
E00042287	298	91	19	32	266
E00042287	298	91	19	32	266
E00042288	304	107	39	39	265
E00042289	263	101	31	57	206
E00042290	265	100	41	43	222
E00042291	260	80	45	35	225
E00042292	226	52	73	32	194
E00042293	290	64	67	41	251
E00042294	278	81	52	40	238
E00042295	369	107	27	29	340
E00042295	369	107	27	29	340
E00042296	256	115	31	41	215
E00042296	256	115	31	41	215
E00042297	289	72	58	38	251
E00042298	235	65	32	72	163
E00042299	340	97	40	30	310
E00042299	340	97	40	30	310
E00042300	277	90	31	31	246
E00042301	334	93	34	45	289
E00042301	334	93	34	45	289
E00042302	312	79	42	35	277
E00042303	225	99	38	43	182
E00042303	225	99	38	43	182
E00042304	297	103	40	40	257
E00042304	297	103	40	40	257
E00042305	327	112	33	45	282
E00042306	246	88	46	37	209
E00042306	246	88	46	37	209
E00042307	265	70	25	38	227
E00042308	336	94	23	42	294
E00042308	336	94	23	42	294
E00042309	246	64	50	53	193
E00042310	171	76	40	47	124
E00042311	216	87	32	42	174
E00042312	262	83	41	49	213
E00042313	301	78	35	37	264

E00042314	267	76	48	44	223
E00042315	267	77	40	42	226
E00042316	343	92	39	48	295
E00042317	377	94	41	52	325
E00042318	405	103	29	40	365
E00042319	301	69	50	45	256
E00042320	263	60	56	39	224
E00042321	157	63	19	58	100
E00042322	256	87	35	49	207
E00042323	316	80	61	45	271
E00042324	333	98	60	52	281
E00042325	257	74	45	42	215
E00042326	358	77	53	53	305
E00042327	270	86	44	38	232
E00042328	369	86	51	58	311
E00042329	196	103	31	21	175
E00042330	207	92	28	39	168
E00042331	201	79	24	41	160
E00042332	533	88	120	62	471
E00042333	289	84	36	45	244
E00042334	281	108	32	46	235
E00042335	319	100	42	44	275
E00042336	255	116	39	75	180
E00042337	310	93	46	60	250
E00042338	394	109	51	64	330
E00042339	318	112	34	50	268
E00042340	276	78	33	30	246
E00042341	268	55	53	38	230
E00042342	284	69	44	39	245
E00042343	297	85	46	52	245
E00042344	202	51	51	20	182
E00042345	294	65	41	49	245
E00042347	312	104	47	42	270
E00042348	309	70	25	40	269
E00042349	389	70	62	55	334
E00042350	407	74	59	66	342
E00042351	281	65	31	42	239
E00042352	293	87	22	47	246
E00042353	268	71	47	44	224
E00042354	325	74	40	43	282
E00042355	355	74	48	48	307
E00042356	414	70	52	45	369
E00042357	471	80	44	77	394
E00042357	471	80	44	77	394
E00042358	132	39	16	19	113

E00042359	165	63	12	34	131
E00042360	315	86	55	48	267
E00042361	249	62	56	38	211
E00042362	225	104	35	42	183
E00042363	294	53	64	49	245
E00042364	266	72	60	66	200
E00042365	249	73	56	48	202
E00042366	253	77	47	27	226
E00042367	222	87	36	32	190
E00042368	328	67	58	57	271
E00042369	220	84	27	37	183
E00042370	266	115	40	101	166
E00042370	266	115	40	101	166
E00042371	306	55	94	40	266
E00042371	306	55	94	40	266
E00042372	259	88	37	42	217
E00042373	360	35	91	43	317
E00042374	310	27	97	30	280
E00042374	310	27	97	30	280
E00042375	277	68	69	46	231
E00042375	277	68	69	46	231
E00042376	240	52	50	23	217
E00042377	270	88	35	52	218
E00042378	353	39	95	41	312
E00042378	353	39	95	41	312
E00042379	352	52	118	29	323
E00042379	352	52	118	29	323
E00042380	417	74	99	53	364
E00042381	279	41	80	33	246
E00042382	247	83	64	50	197
E00042383	489	44	94	39	450
E00042384	392	54	83	42	350
E00042385	349	44	86	38	311
E00042386	313	43	76	30	283
E00042387	232	43	65	37	195
E00042388	449	97	118	91	358
E00042389	274	30	66	31	243
E00042390	164	70	27	37	127
E00042391	279	43	58	35	244
E00042392	196	77	38	25	171
E00042393	294	85	35	29	265
E00042394	330	58	60	42	288
E00042395	200	69	35	37	163
E00042396	203	88	43	40	163
E00042397	440	65	151	53	387

E00042398	253	63	49	60	193
E00042399	313	63	66	43	270
E00042400	353	69	53	87	266
E00042401	305	46	76	47	258
E00042402	229	57	71	31	198
E00042403	400	91	89	62	338
E00042404	352	58	83	60	292
E00042405	268	42	88	25	243
E00042406	578	65	145	14	564
E00042407	298	42	68	45	253
E00042408	373	50	69	33	340
E00042409	272	51	96	27	245
E00042410	306	53	108	12	294
E00042411	250	52	62	3	247
E00042412	356	57	63	7	349
E00042413	363	68	61	13	350
E00042414	232	38	60	10	222
E00042415	328	79	74	17	311
E00042416	233	70	53	33	200
E00042417	247	89	46	52	195
E00042418	303	47	77	16	287
E00042419	405	57	118	24	381
E00042420	268	59	77	44	224
E00042421	218	39	65	22	196
E00042422	356	36	85	38	318
E00042423	324	41	68	34	290
E00042424	310	44	95	19	291
E00042425	328	41	72	30	298
E00042426	326	52	84	12	314
E00042427	388	72	104	16	372
E00042428	344	62	98	8	336
E00042429	323	38	56	15	308
E00042430	244	39	81	20	224
E00042431	249	43	48	16	233
E00042432	362	70	75	20	342
E00042433	237	34	47	12	225
E00042434	259	67	66	24	235
E00042435	354	69	64	18	336
E00042436	232	49	61	10	222
E00042437	317	69	62	26	291
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042438	401	66	59	12	389
E00042439	598	86	111	9	589
E00042439	598	86	111	9	589

E00042440	355	46	80	24	331
E00042440	355	46	80	24	331
E00042441	429	75	101	18	411
E00042441	429	75	101	18	411
E00042442	524	46	110	11	513
E00042442	524	46	110	11	513
E00042443	424	64	119	8	416
E00042443	424	64	119	8	416
E00042444	432	54	101	10	422
E00042445	220	43	64	54	166
E00042446	352	44	78	11	341
E00042447	385	53	80	6	379
E00042447	385	53	80	6	379
E00042448	542	33	109	9	533
E00042448	542	33	109	9	533
E00042448	542	33	109	9	533
E00042449	321	24	82	16	305
E00042450	609	50	133	7	602
E00042451	379	74	91	15	364
E00042451	379	74	91	15	364
E00042451	379	74	91	15	364
E00042452	513	53	104	9	504
E00042453	286	71	57	26	260
E00042453	286	71	57	26	260
E00042453	286	71	57	26	260
E00042454	340	40	85	8	332
E00042455	430	44	87	43	387
E00042455	430	44	87	43	387
E00042456	295	44	65	34	261
E00042457	616	51	94	4	612
E00042457	616	51	94	4	612
E00042458	435	63	104	18	417
E00042458	435	63	104	18	417
E00042458	435	63	104	18	417
E00042459	475	42	89	15	460
E00042459	475	42	89	15	460
E00042460	414	42	81	12	402
E00042460	414	42	81	12	402
E00042461	384	34	92	26	358
E00042461	384	34	92	26	358
E00042462	448	54	90	25	423
E00042462	448	54	90	25	423
E00042463	390	55	94	17	373
E00042463	390	55	94	17	373
E00042464	317	56	105	31	286

E00042464	317	56	105	31	286
E00042465	436	50	71	1	435
E00042466	301	45	74	91	210
E00042466	301	45	74	91	210
E00042467	345	47	118	10	335
E00042468	448	93	134	39	409
E00042468	448	93	134	39	409
E00042469	226	81	51	38	188
E00042469	226	81	51	38	188
E00042470	370	33	100	33	338
E00042471	326	54	81	33	293
E00042471	326	54	81	33	293
E00042471	326	54	81	33	293
E00042472	189	58	53	50	139
E00042473	349	31	85	34	315
E00042474	237	41	64	38	199
E00042475	338	27	74	3	335
E00042476	512	46	99	8	504
E00042477	460	47	100	10	450
E00042478	367	108	38	37	330
E00042478	367	108	38	37	330
E00042479	311	116	19	64	247
E00042479	311	116	19	64	247
E00042480	321	59	65	41	280
E00042481	363	71	41	40	323
E00042482	300	77	57	47	253
E00042483	310	42	73	37	273
E00042484	271	52	62	29	242
E00042485	302	77	49	48	254
E00042486	222	85	26	41	181
E00042487	351	69	58	51	300
E00042488	254	71	44	39	215
E00042489	295	46	66	36	259
E00042490	326	79	55	44	282
E00042491	507	112	114	99	410
E00042492	328	71	56	42	286
E00042493	249	69	47	40	209
E00042494	282	69	36	31	251
E00042495	193	88	42	16	177
E00042496	335	46	92	69	266
E00042498	299	63	63	50	249
E00042499	333	68	55	49	284
E00042500	401	59	76	76	325
E00042501	218	54	50	45	173
E00042502	388	44	91	45	343

E00042503	367	85	33	42	325
E00042504	228	89	36	35	193
E00042505	260	65	44	32	228
E00042505	260	65	44	32	228
E00042506	167	104	16	44	123
E00042507	467	148	31	64	403
E00042507	467	148	31	64	403
E00042508	195	94	41	36	159
E00042509	362	104	40	66	296
E00042510	294	94	29	38	256
E00042510	294	94	29	38	256
E00042511	293	62	60	46	248
E00042512	310	44	74	42	268
E00042513	301	81	43	49	252
E00042514	311	56	63	30	281
E00042515	258	65	51	23	235
E00042516	363	92	32	37	326
E00042517	240	74	55	26	214
E00042518	250	78	32	38	212
E00042519	318	62	58	25	293
E00042520	265	59	52	44	221
E00042521	319	86	37	64	255
E00042522	325	59	92	45	280
E00042523	331	93	42	43	288
E00042524	288	99	30	47	241
E00042525	369	117	23	86	283
E00042526	324	88	42	42	282
E00042527	234	64	61	27	207
E00042528	317	88	39	37	280
E00042529	237	53	53	38	199
E00042530	289	76	50	26	263
E00042531	260	85	42	52	208
E00042532	293	75	52	41	252
E00042533	269	77	58	23	246
E00042534	247	84	32	46	201
E00042535	266	58	57	16	250
E00042536	287	76	56	41	246
E00042537	306	100	47	58	249
E00042538	287	74	65	41	246
E00042539	256	58	53	33	223
E00042540	262	86	44	52	210
E00042541	278	67	45	39	239
E00042542	273	66	58	19	254
E00042543	266	69	59	34	232
E00042544	285	84	40	52	233

E00042545	288	86	31	54	234
E00042546	272	52	67	16	256
E00042547	394	167	45	57	337
E00042548	270	86	26	39	231
E00042549	386	109	43	52	334
E00042550	318	115	27	36	282
E00042551	296	108	20	43	253
E00042552	170	102	13	46	124
E00042553	342	102	39	42	300
E00042554	286	80	47	40	246
E00042555	380	118	43	61	319
E00042556	238	92	43	32	206
E00042557	306	79	53	25	281
E00042558	200	71	39	19	181
E00042559	354	110	29	30	324
E00042560	325	104	29	31	294
E00042561	254	95	29	25	229
E00042562	290	99	23	30	260
E00042563	281	93	17	33	248
E00042564	307	85	26	34	273
E00042565	199	95	29	19	180
E00042566	327	108	38	48	279
E00042567	282	93	21	38	244
E00042568	246	92	20	35	211
E00042569	215	89	22	54	161
E00042570	349	110	33	49	300
E00042571	210	95	20	47	163
E00042572	304	91	38	39	265
E00042573	203	80	21	35	168
E00042574	328	110	42	52	276
E00042575	308	111	28	37	271
E00042576	376	89	39	39	337
E00042577	274	110	35	37	237
E00042578	313	82	34	45	268
E00042579	196	117	35	9	187
E00042579	196	117	35	9	187
E00042580	447	98	86	5	442
E00042581	261	107	19	56	205
E00042582	263	94	24	37	226
E00042583	174	35	25	5	169
E00042583	174	35	25	5	169
E00042584	241	126	22	62	179
E00042585	245	80	16	36	209
E00042586	438	126	33	61	377
E00042587	295	100	27	38	257

E00042588	370	94	36	45	325
E00042588	370	94	36	45	325
E00042588	370	94	36	45	325
E00042589	305	114	34	33	272
E00042590	271	112	31	52	219
E00042591	247	95	29	26	221
E00042592	151	106	18	11	140
E00042593	319	215	32	27	292
E00042594	208	45	57	7	201
E00042595	171	117	4	92	79
E00042596	179	113	19	38	141
E00042597	200	43	64	11	189
E00042598	315	71	80	16	299
E00042599	196	62	43	12	184
E00042600	338	74	67	24	314
E00042601	132	76	24	9	123
E00042604	545	52	59	7	538
E00042605	498	57	59	2	496
E00042606	406	91	56	39	367
E00042607	383	91	50	47	336
E00042608	443	100	44	66	377
E00042608	443	100	44	66	377
E00042609	496	65	84	24	472
E00042610	292	89	42	53	239
E00042611	344	84	83	41	303
E00042612	198	104	19	57	141
E00042613	329	95	43	48	281
E00042614	284	87	43	47	237
E00042615	286	71	56	42	244
E00042616	266	86	35	37	229
E00042617	318	63	69	41	277
E00042618	220	70	48	44	176
E00042619	277	62	56	58	220
E00042620	258	74	46	37	221
E00042621	255	90	27	37	218
E00042622	297	71	59	60	237
E00042623	300	91	30	36	264
E00042624	339	81	56	46	293
E00042625	286	76	47	42	244
E00042626	358	70	78	47	311
E00042627	254	83	33	55	199
E00042628	386	97	35	86	300
E00042629	287	113	29	64	223
E00042630	152	63	16	22	130
E00042631	198	85	34	21	177

E00042632	263	97	32	48	215
E00042633	290	96	39	49	241
E00042634	319	78	43	41	278
E00042635	219	72	39	23	196
E00042636	274	86	57	41	233
E00042637	534	128	112	76	458
E00042638	251	86	43	21	230
E00042639	250	58	59	26	224
E00042640	244	55	70	20	224
E00042641	357	39	99	14	343
E00042642	413	90	84	24	389
E00042643	441	76	75	28	413
E00042643	441	76	75	28	413
E00042643	441	76	75	28	413
E00042644	333	48	72	13	320
E00042645	443	73	99	8	435
E00042646	255	99	23	25	230
E00042647	218	49	46	15	203
E00042647	218	49	46	15	203
E00042648	305	88	72	62	243
E00042649	294	51	64	10	284
E00042650	356	60	88	27	329
E00042651	329	52	73	13	316
E00042652	218	44	72	17	201
E00042653	467	61	103	2	465
E00042654	187	117	23	52	135
E00042655	247	45	50	6	241
E00042656	358	52	84	31	327
E00042656	358	52	84	31	327
E00042656	358	52	84	31	327
E00042657	408	52	89	26	382
E00042657	408	52	89	26	382
E00042658	371	61	62	18	353
E00042658	371	61	62	18	353
E00042658	371	61	62	18	353
E00042659	373	45	81	24	349
E00042659	373	45	81	24	349
E00042659	373	45	81	24	349
E00042661	110	74	16	10	100
E00042662	300	53	65	12	288
E00042662	300	53	65	12	288
E00042663	232	46	46	13	219
E00042664	269	80	47	20	249
E00042664	269	80	47	20	249
E00042664	269	80	47	20	249

E00042665	152	115	14	30	122
E00042666	334	91	56	16	318
E00042666	334	91	56	16	318
E00042667	198	31	49	6	192
E00042668	281	63	59	10	271
E00042668	281	63	59	10	271
E00042669	261	35	14	9	252
E00042670	369	111	35	40	329
E00042671	126	63	25	16	110
E00042671	126	63	25	16	110
E00042672	1161	71	19	13	1148
E00042672	1161	71	19	13	1148
E00042673	340	117	56	25	315
E00042673	340	117	56	25	315
E00042674	247	128	40	52	195
E00042677	244	115	43	29	215
E00042679	590	71	37	1	589
E00042681	365	54	85	18	347
E00042682	408	55	90	17	391
E00042683	275	38	98	7	268
E00042685	120	41	13	20	100
E00042686	286	73	48	43	243
E00042686	286	73	48	43	243
E00042687	306	75	47	40	266
E00042687	306	75	47	40	266
E00042688	246	65	49	24	222
E00042688	246	65	49	24	222
E00042689	341	89	45	40	301
E00042690	302	95	34	45	257
E00042691	205	76	9	33	172
E00042693	336	122	23	52	284
E00042694	225	72	13	43	182
E00042695	189	130	3	84	105
E00042697	337	131	26	75	262
E00042697	337	131	26	75	262
E00042702	269	79	40	23	246
E00042702	269	79	40	23	246
E00042703	250	67	53	31	219
E00042703	250	67	53	31	219
E00042704	319	64	61	34	285
E00042704	319	64	61	34	285
E00042705	260	65	56	32	228
E00042705	260	65	56	32	228
E00042706	373	42	99	55	318
E00042706	373	42	99	55	318

E00042706	373	42	99	55	318
E00042707	415	32	121	65	351
E00042707	415	32	121	65	351
E00042707	415	32	121	65	351
E00042708	292	29	87	24	268
E00042708	292	29	87	24	268
E00042709	332	58	74	44	288
E00042710	324	55	90	43	281
E00042710	324	55	90	43	281
E00042711	236	28	90	24	212
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042712	301	36	100	32	269
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042713	509	99	139	138	372
E00042714	266	43	81	52	214
E00042715	292	43	84	43	249
E00042716	288	53	76	33	255
E00042717	544	85	148	43	501
E00042717	544	85	148	43	501
E00042717	544	85	148	43	501
E00042718	260	48	82	29	231
E00042719	310	43	89	45	265
E00042720	277	39	76	36	241
E00042721	376	48	82	69	307
E00042722	299	41	101	26	273
E00042723	360	54	77	55	305
E00042724	369	41	110	54	315
E00042725	385	49	99	83	305
E00042725	385	49	99	83	305
E00042726	324	33	113	24	300
E00042726	324	33	113	24	300
E00042726	324	33	113	24	300
E00042727	354	37	102	17	337
E00042727	354	37	102	17	337
E00042728	354	33	91	42	312
E00042728	354	33	91	42	312
E00042729	314	27	89	35	279
E00042729	314	27	89	35	279
E00042730	338	76	69	79	259
E00042731	336	36	94	42	294
E00042732	244	43	86	29	215
E00042733	450	62	50	65	385
E00042734	245	58	67	34	211

E00042735	250	27	86	25	225
E00042735	250	27	86	25	225
E00042735	250	27	86	25	225
E00042736	325	32	95	35	290
E00042737	270	42	93	32	239
E00042738	246	33	96	19	227
E00042739	319	25	87	38	281
E00042739	319	25	87	38	281
E00042739	319	25	87	38	281
E00042740	336	116	18	51	285
E00042741	324	80	33	31	293
E00042742	322	106	23	33	289
E00042743	311	144	30	30	281
E00042745	388	95	30	109	280
E00042746	290	76	40	37	253
E00042747	253	74	61	15	238
E00042748	245	73	37	43	202
E00042750	157	85	9	25	132
E00042751	117	83	14	18	99
E00042752	119	45	12	15	104
E00042753	127	88	11	9	118
E00042754	225	93	11	38	187
E00042755	135	83	11	13	122
E00042756	302	91	33	33	269
E00042757	213	89	23	34	179
E00042758	298	98	29	54	244
E00042759	327	118	14	95	232
E00042760	341	124	29	98	244
E00042761	321	112	16	37	284
E00042762	280	100	25	32	248
E00042763	289	108	25	47	242
E00042764	384	97	35	58	326
E00042765	251	160	36	9	242
E00042766	268	138	25	52	216
E00042767	350	106	47	51	299
E00042768	241	79	41	30	211
E00042769	301	72	56	27	274
E00042770	280	95	41	54	226
E00042771	259	83	43	40	219
E00042772	334	64	67	36	298
E00042773	232	82	36	57	175
E00042774	217	86	20	33	184
E00042775	356	78	66	47	309
E00042776	388	92	75	36	352
E00042777	264	80	41	43	221

E00042778	231	87	39	36	195
E00042779	244	84	18	22	222
E00042780	298	71	44	39	259
E00042781	232	82	37	46	187
E00042782	307	57	58	30	277
E00042783	297	109	33	71	226
E00042784	219	90	33	52	167
E00042785	231	72	35	28	203
E00042786	344	61	63	29	316
E00042787	322	184	49	36	286
E00042788	266	144	27	32	234
E00042789	308	81	55	44	264
E00042790	243	117	15	63	180
E00042791	300	90	22	59	241
E00042792	291	99	32	38	253
E00042793	302	68	33	30	272
E00042794	366	77	66	43	323
E00042795	358	87	57	47	311
E00042796	279	69	51	28	251
E00042797	186	89	25	41	145
E00042798	305	87	25	34	271
E00042799	219	80	39	20	199
E00042800	237	65	47	23	214
E00042801	296	89	37	44	252
E00042802	332	74	56	43	289
E00042803	391	137	24	50	341
E00042805	222	126	9	34	188
E00042806	293	86	32	38	255
E00042807	195	121	22	17	178
E00042808	275	92	27	48	227
E00042810	316	100	17	36	280
E00042811	391	110	14	32	359
E00042811	391	110	14	32	359
E00042812	178	136	12	32	146
E00042812	178	136	12	32	146
E00042814	256	100	20	54	202
E00042816	128	41	13	13	115
E00042818	191	130	24	12	179
E00042819	171	104	34	2	169
E00042820	193	47	29	21	172
E00042822	291	95	56	2	289
E00042823	285	118	21	36	249
E00042824	314	127	15	55	259
E00042825	363	104	74	11	352
E00042826	400	148	94	7	393

E00042827	401	110	26	50	352
E00042828	313	79	56	30	283
E00042829	316	145	85	9	307
E00042830	198	135	21	11	187
E00042831	357	96	38	93	264
E00042832	268	91	33	62	206
E00042833	331	94	48	40	291
E00042834	295	47	65	22	273
E00042835	263	68	54	50	213
E00042835	263	68	54	50	213
E00042836	309	69	49	43	266
E00042837	282	56	69	42	240
E00042838	341	59	77	50	291
E00042839	248	78	42	56	192
E00042839	248	78	42	56	192
E00042840	224	99	22	51	173
E00042841	228	77	36	33	195
E00042842	268	64	55	44	224
E00042842	268	64	55	44	224
E00042843	312	100	45	67	245
E00042844	297	70	59	37	260
E00042845	245	65	52	58	187
E00042845	245	65	52	58	187
E00042846	259	87	45	60	199
E00042846	259	87	45	60	199
E00042847	296	65	59	50	246
E00042848	342	91	51	61	281
E00042849	295	87	45	61	234
E00042850	256	96	34	39	217
E00042851	295	79	50	37	258
E00042852	353	47	86	30	323
E00042853	251	80	43	56	195
E00042854	247	74	43	53	194
E00042854	247	74	43	53	194
E00042855	258	66	55	43	215
E00042855	258	66	55	43	215
E00042856	271	67	55	45	226
E00042856	271	67	55	45	226
E00042857	343	79	61	34	309
E00042858	288	66	59	48	240
E00042858	288	66	59	48	240
E00042859	340	53	80	30	310
E00042860	268	81	46	62	206
E00042861	262	87	47	48	214
E00042862	248	80	43	58	190

E00042862	248	80	43	58	190
E00042863	314	83	51	49	265
E00042864	301	66	66	35	266
E00042865	327	74	67	33	294
E00042866	293	64	68	55	238
E00042867	317	50	71	30	287
E00042868	272	36	67	23	249
E00042869	319	55	80	37	282
E00042870	302	53	76	33	269
E00042871	282	68	60	36	246
E00042872	280	53	75	31	249
E00042873	325	75	62	26	299
E00042874	557	91	75	34	523
E00042874	557	91	75	34	523
E00042875	359	79	46	39	321
E00042875	359	79	46	39	321
E00042876	405	68	58	49	356
E00042877	486	81	60	47	439
E00042877	486	81	60	47	439
E00042878	487	74	55	88	399
E00042879	430	85	37	52	378
E00042879	430	85	37	52	378
E00042880	352	55	59	40	312
E00042881	278	66	62	27	251
E00042881	278	66	62	27	251
E00042882	388	99	36	51	337
E00042882	388	99	36	51	337
E00042883	353	96	58	48	305
E00042884	243	68	61	35	209
E00042884	243	68	61	35	209
E00042885	289	82	51	40	249
E00042886	280	75	85	44	236
E00042887	345	85	50	58	288
E00042888	339	97	48	50	289
E00042889	405	81	63	64	342
E00042890	406	116	43	70	336
E00042891	266	31	82	35	231
E00042892	347	98	37	62	285
E00042893	313	57	59	43	270
E00042894	359	68	44	54	306
E00042895	291	50	63	42	249
E00042896	308	43	68	31	277
E00042897	398	52	65	106	292
E00042898	357	71	55	42	315
E00042899	493	79	68	42	451

E00042899	493	79	68	42	451
E00042900	509	61	77	33	476
E00042901	360	56	54	24	336
E00042902	372	73	50	62	310
E00042902	372	73	50	62	310
E00042903	374	87	50	48	326
E00042904	319	101	22	50	269
E00042905	200	93	26	25	175
E00042906	272	105	25	51	221
E00042907	311	114	40	59	252
E00042908	308	96	45	36	272
E00042909	264	112	46	51	213
E00042910	293	62	70	56	237
E00042911	334	70	61	71	263
E00042912	495	66	113	72	423
E00042913	281	80	55	52	229
E00042914	280	88	27	49	231
E00042915	321	84	37	40	281
E00042916	386	88	25	100	287
E00042917	294	96	30	29	265
E00042918	362	95	32	42	320
E00042919	359	95	42	53	306
E00042920	374	88	30	71	303
E00042921	336	102	23	52	284
E00042922	293	91	25	51	242
E00042923	288	65	61	33	255
E00042924	259	82	29	48	211
E00042925	251	101	20	60	191
E00042926	303	90	26	63	240
E00042927	268	102	18	41	227
E00042928	348	117	51	48	300
E00042929	258	85	38	53	205
E00042930	199	57	48	22	177
E00175550	249	93	44	12	237
E00175551	225	67	61	10	215
E00175552	223	100	50	7	216
E00175553	236	80	41	1	235
E00175554	443	135	46	56	387
E00175555	417	55	57	4	413
E00175556	124	51	24	19	105
E00175557	144	56	33	4	140
E00175558	216	68	53	6	210
E00175559	206	66	57	7	199
E00175560	202	61	68	16	186
E00175561	225	112	27	2	223

E00175561	225	112	27	2	223
E00175562	349	99	29	54	295
E00175563	192	43	80	6	186
E00175564	354	38	34	3	351
E00175565	559	30	47	25	534
E00175566	241	59	57	59	182
E00175567	370	28	89	45	325
E00175568	348	20	93	46	302
E00175569	371	18	96	61	310
E00175570	396	30	86	46	350
E00175571	289	33	88	37	252
E00175572	150	60	25	37	113
E00175573	330	28	90	40	290
E00175574	623	31	32	2	621
E00175575	194	80	45	9	185
E00175576	165	69	44	2	163
E00175577	375	101	38	99	276
E00175578	891	81	29	9	882
E00175579	167	75	52	2	165
E00175580	237	64	89	9	228
E00175581	261	106	23	28	233
E00175582	363	117	38	60	303
E00175583	239	69	35	23	216
E00175584	1346	30	14	17	1329
E00175585	201	50	43	1	200
E00175586	336	95	24	62	274
E00175587	150	61	40	32	118
E00175588	167	86	19	33	134
E00175589	500	63	41	34	466
E00175590	206	33	65	22	184
E00175591	265	26	76	29	236
E00175592	201	123	15	42	160
E00175593	600	55	55	2	598
E00175594	282	41	43	3	279
E00175595	116	48	14	0	116
E00175596	279	75	25	34	245
E00175597	421	101	46	36	385
E00175597	421	101	46	36	385
E00175597	421	101	46	36	385
E00175598	612	40	48	4	608
E00175599	364	153	46	65	299
E00175600	150	61	28	15	135
E00175601	156	28	32	23	133
E00175602	227	23	67	26	201
E00175603	259	49	43	36	223

E00175604	232	47	51	24	208
E00175605	214	51	38	34	180
Total	**338730**	**82440**	**57932**	**42397**	**296397**